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SEVENTEENTH ANNUAL REPORT

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COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH,

FOR THE

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COMMONWEALTH OF AUSTRALIA.

Council for Scientific and Industrial Research.

SEVENTEENTH ANNUAL REPORT (FOR YEAR ENDED 30TH JUNE, 1943).

NOTE.—*A very considerable part of the Council's activities is now devoted to the solution of problems arising out of the war and to assistance and advice to various Government Departments and other institutions and organizations which are concerned with the war effort. This applies particularly to the Council's National Standards Laboratory, and the Divisions of Aeronautics, Forest Products, and Industrial Chemistry. The expenditure on this class of work forms a substantial part of the total expenditure of the Council, but as no specific information which might be of value to the enemy can be disclosed, reference to these activities is either confined to brief generalized statements or is omitted entirely.*

I. INTRODUCTORY AND GENERAL.

1. GENERAL.

The Council for Scientific and Industrial Research was established in 1926 by the re-organization of the existing Institute of Science and Industry. The powers and functions of the Council are defined by the *Science and Industry Research Act* 1920-1939, and include the initiation and carrying out of research in connexion with, or for the promotion of, primary and secondary industries; the training of research workers; the making of grants in aid of pure research; the testing and standardization of scientific apparatus and instruments, and the carrying out of scientific investigations connected with standardization; and the establishment of a bureau of information relating to scientific and technical matters.

2. FINANCE.

The total expenditure of the Council during the financial year 1942-43 was £541,283, of which £106,126 was contributed from sources other than the Commonwealth Treasury. The Council is particularly gratified with the way in which contributory bodies continue to support it and with the marked interest and donations for co-operative research received from certain sections of industry. Among the many contributions received, reference may be made to those of the Commonwealth Bank, the Australian Wool Board, the Australian Cattle Research Association, the George Aitken Pastoral Research Trust, the Dried Fruits Control Board, the New South Wales Water Conservation and Irrigation Commission, the Cement Manufacturers' Association, the timber industry, and the pulp and paper industry.

II. PLANT INVESTIGATIONS.

1. GENERAL.

The work of the Division of Plant Industry has followed the lines reported last year, and, despite the handicap of short staff, satisfactory progress is evident. The opportunity is taken to thank individuals, institutions, and other Government departments for co-operation given on many occasions, without which it would be impossible to do the work.

The Commonwealth Vegetable Seeds Committee, established by the Minister for Commerce as a result of representations made by a Conference in January, 1942, operated under the chairmanship of the Chief of the Division, with Dr. J. R. A. McMillan as Executive Officer, until January, 1943. The year was one of great difficulty because of seed shortages and greatly increased requirements, because of the limited experience of many growers, and the need nevertheless to grow seed crops of essential vegetables in quantity. By the co-operation of growers, seeds merchants, State Departments of Agriculture, and the Department of Commerce, a considerable measure of success was achieved and the foundation laid for the development of a permanent industry. On the appointment of a Director-General of Agriculture, in the Department of Commerce and Agriculture, the Committee was reconstituted with departmental personnel as a Committee of that Department; Dr. Dickson is Deputy Chairman and Dr. McMillan Executive Member. The need for the Committee is evident in that Dr. McMillan is devoting full time to the work. The Council is providing office accommodation for the Committee for the time being. It has been necessary to withdraw Mr. Christian from Lawes to supervise the work of the plant improvement and genetics group.

The regular Conference between the Council and State officers concerned with tobacco investigations and production was held in Canberra in July, 1942. Consideration was given to the labour and materials requirements of the industry in order to grow the crop, and it was evident that a harvest of not more than 4,500,000 lb. could be expected during the 1942-43 season. It was also agreed that a detailed survey of land, equipment, labour, &c., available be undertaken so that an estimate could be made of maximum acreage that could be planted with tobacco without making demands on materials and supplies required for more urgent war purposes. A grading scheme based on leaf position was discussed, and Conference decided to refer it for opinions to interested parties and to review it at the 1943 Conference.

Investigations leading to the production of essential drug plants, including those on poppy, pyrethrum, *Cinchona*, *Duboisia*, and *Ephedra*, are being actively prosecuted, and considerable advances have been made in ensuring supplies. In this work, the Medical Equipment Control Committee, the National Health and Medical Research Council, the Department of Pharmacy of Sydney University, the Physiology Department of Melbourne University, and the Forestry Department of Queensland, are co-operating.

Special attention is being paid to studies of plants likely to serve as a source of rubber, particularly guayule and *Taraxacum koksaghyz*.

Work is being continued on microbiological retting of flax with some interesting results which may have an important bearing on the process. In the anatomical studies of flax the co-operation of the Department of Botany of the University of Sydney is acknowledged.

With the concentration of effort on war problems, much of the horticultural work in Tasmania has given place to joint work on dehydration problems with the Department of Commerce and Agriculture, the Department of Supply and Shipping, and the Division of Food Preservation and Transport.

For some years the plan to establish a plant introduction programme in Western Australia has been in mind, and during the year this was effected with the co-operation of the Department of Agriculture. During the war the work will be mainly with trials of special plants of immediate importance to the war effort, such as rubber, drug, and selected vegetables, but attention will also be paid to pasture plants for use during the reconstruction period.

As opportunity presents itself, the layout of the Dickson Experiment Station, A.C.T., is being forwarded and the main entrance avenue has been planted.

2. Pasture Investigations.

(i) *Agrostology.*

(*a*) *Western Australia.*—The main work has been concerned with (1) pasture mixture trials in the south-west Division and the control of capeweed, (2) perennial veldt grass, and (3) lupins.

(1) Pasture Mixture Trials.—The initial failures of 1939 and 1940 in the establishment of sown pasture mixtures were partly due to seasonal conditions and partly to heavy infestations of capeweed. At Cranmore Park, Walebing (17½ inches rainfall p.a.), successful stands of Wimmera ryegrass, perennial veldt grass, and *Phalaris tuberosa* with early subterranean clover were obtained in 1942. The experimental area was on a paddock of natural pasture, carefully prepared and fallowed, and was free of capeweed. On the single cut in November, 1942, Wimmera ryegrass gave the highest yield—26 cwt. per acre, followed by perennial veldt grass—15 cwt. per acre, and *Phalaris tuberosa*—9 cwt. per acre.

An experiment to control capeweed at the Avondale Experiment Farm has shown that late seeding and the use of oats as a cover crop greatly reduce the infestation of the weed. This advantage does not offset the depressing effect of late seeding or the depressing effect of the oats on the establishment of the sown pasture plants.

(2) Perennial Veldt Grass.—This accidental introduction from South Africa which flourishes on the poor coastal sands has been observed to be extremely palatable. Furthermore, an interesting point is that grazing has the effect of prolonging the stage during which the grass remains green. An experiment is planned to study in detail the effect of frequency of grazing on a pasture of perennial veldt grass and subterranean clover. A wide range of superior plant types has been selected, and a basic collection of 250 selections is being maintained. Types which do not readily shed seed have been found among them, and the character for non-shedding has been proved to be a single recessive. It is hoped later to overcome the great practical difficulties of seed harvesting by combining the non-shedding character with other desirable characteristics.

(3) Blue Lupins.—Because of the local incidence of a virus of the pea mosaic type, work on this species has been curtailed. Early sowing and the use of superphosphate are both conducive to higher yields.

(*b*) *Queensland.*—Until it is possible to implement the programme for which the St. Lucia laboratories were designed, the main studies in this State are at "Gilruth Plains"; they have been concerned chiefly with the Mitchell grass association. Experiments on this grass at present in progress include (1) a grazing trial, (2) studies on the cutting of the grass for hay, (3) its re-establishment on areas from which it has disappeared, (4) changes in its chemical composition throughout the year, and (5) soil moisture studies. The work was commenced in 1941 after excellent summer rains and with the Mitchell grass pasture in good condition. After a good fall in March, 1941, effective rains were not again experienced until May, 1942, when 2¾ inches fell. Dry conditions again prevailed until December, when 8 inches of rain resulted in heavy pasture growth. As in 1940-41, this growing period, only seven to eight weeks, was of short duration.

(1) Grazing Trial.—The objectives of this trial are to study the effect on the pasture and on the sheep of grazing Mitchell grass with sheep at different rates and frequencies. From a yield of approximately 17 cwt. dry material per acre at the initial sampling in February, 1941, the grazing residue declined steadily to approximately 4 cwt. per acre in October, 1942. The growth of herbage following on the May, 1942, rains was too small to reverse the downward trend of yields. The decline has been consistently greater with the heavier rate of stocking. There is little difference in the grazing residue between the medium and light rates of stocking (one sheep to 5 acres and one sheep to 7½ acres p.a. respectively), but at the heavy rate (one sheep to 2½ acres p.a.) the effect of the heavier grazing is shown in a decreased residue. Rotational (six months' grazing and six months' rest) and continuous grazing at all rates of stocking give in general very similar results. A high proportion of the total available feed has been lost in both summer seasons due to causes other than grazing, *e.g.*, breaking up of the very dry feed. No marked changes in botanical composition due to treatment have so far been recorded, the effect of rainfall over-riding any effect of grazing treatment. Chemical composition has not been affected by differential grazing. However, the miscellaneous herbage species — both summer and winter—are twice as rich in protein, four times as rich in calcium, and nearly twice as rich in phosphorus as the Mitchell grasses. The liveweights of the sheep in general have followed very closely the pasture conditions. The liveweights and wool yields generally decrease with an increase of the intensity of stocking, and there is no difference between the rotationally grazed and continuously grazed flocks.

(2) Studies On the Cutting of Mitchell Grass for Hay.—The object of this work is to study the effect of various cutting treatments on the yield and chemical composition of Mitchell grass hay and also on the persistence of the pasture. The results from Lawes so far indicate that a higher yield of total dry matter and of phosphorus per acre is obtained from cutting 6 inches above ground-level at flowering.

(3) Re-establishment of Mitchell Grass.—Sowings made before and after the 1940-41 summer rains were unsuccessful. The 1941-42 rains were too late to benefit the sowings of that season, but counts will be made to see if there has been a delayed germination of the seed sown to date, as a result of the good rains of the 1942-43 season.

(4) Changes in the Chemical Composition of Mitchell Grass. — The chemical analysis of three species of Mitchell grass at monthly intervals is continuing.

(5) Soil Moisture Studies.—Monthly soil moisture records have been taken for a period of two years on both the brown and grey loam soil types on the Mitchell grass plain country. The results have shown that the penetration of the rainfall is surprisingly slight. Over two seasons, heavy rains have penetrated to only the 3 ft. level, and moisture has been withdrawn by plants barely to this depth. Following summer rains, plant growth exhausts the readily available soil moisture very rapidly, and growth ceases. Thus the period of active pasture growth is limited to seven or eight weeks by shortage of water.

(*c*) *Australian Capital Territory.*—Pasture investigations centred at Canberra were commenced in 1939 during a very favourable season, and the pastures were well enough established by the spring to enable them to withstand the severe conditions of 1940 and 1941. From November, 1939, to the spring of 1942, the longest period of uninterrupted growth was not more than two months. At this latter period good rains resulted in the first normal spring flush since the establishment of the pasture in 1939.

(1) Pasture Management Experiment.—The differential grazing of a sown pasture mixture of *Phalaris tuberosa,* subterranean clover, and lucerne, involving a comparison of continuous, 4-weekly, and 8-weekly rotations, has been in progress since June, 1940. The pasture is being grazed by Merino wethers and has carried an average of nearly three wethers per acre for this period, although two of the three seasons have been abnormally dry. The pasture has been grazed throughout except for a period of eight weeks in May and June, 1942, when the whole experiment was rested after the opening rains on May 5 to enable the pasture to recover from the severe overgrazing in the summer of 1942. The effect of the three systems of grazing on the yield of pasture has not been great at any time. From August to December, 1940, the yield of the continuous plots was slightly ahead of the 8-weekly rotation. From January, 1941, to June, 1942, the 8-weekly rotation gave the better yield during this period of increasing scarcity of feed. From May, 1942, onwards, with the advent of good autumn rains, the yield of the continuously grazed plots overtook the yield of the 8-weekly rotations and by the spring of 1942 were better, and this better yield was maintained in the summer of 1942-43. In general, the 4-weekly rotation yields have been intermediate between the continuous and 8-weekly rotation. *Phalaris tuberosa* has been the most important contributor to the yield of the pasture on all treatments, except for a short period in the initial stages when subterranean clover was the main constituent. Lucerne was unimportant on all treatments until February, 1941, and it was at this stage that the effect of the rotational grazing on this plant became established. After the summer rains, it made an important contribution to the pasture yields on the 8-weekly rotation but failed to make headway on the continuously grazed plots. This position has been substantially maintained in subsequent spring and summer analyses. The chemical composition of the pasture has been at a high level throughout the experiment. The absence of any marked change is attributable to the dry conditions and the absence of a spring flush of growth. The high values for protein, even in the dried-off herbage, together with the satisfactory lime content, means that the stock have had pasture of satisfactory nutritive value from July, 1940, onward. The grazing treatments so far do not appear to have had any marked effect on the chemical composition of the pasture. The gain or loss in liveweights of the sheep are almost entirely a reflex of the pasture conditions as a whole, and these fluctuations in liveweights are closely correlated with the quantity and quality of the food supply. Until October, 1941, all sheep gained weight, but the rapid loss in weight from that date was less on the 8-weekly rotation flocks than on the continuously grazed flocks, reaching a difference of 6 to 8 lb. per head in March, 1942. Under the good grazing conditions of 1942, the continuously grazed flocks gained on the rotationally grazed flocks, and by January, 1944, had practically closed the gap in bodyweight gains. There is no effect on the weight of greasy wool per head, scoured yield, staple length, or appraised value per pound of the wool grown on the three grazing treatments at the October, 1941, and October, 1942, shearings. The sheep have been singularly free from infestation by internal parasites throughout. At no stage have the sheep been drenched. Grazing treatment has not affected infection rates.

(2) Deficiency Diseases of Legumes.—The unsatisfactory growth of lucerne and of subterranean clover—a trouble that is widespread on the southern tablelands—is now regarded as a symptom of lime deficiency. Field trials have given inconsistent responses to lime, but this is attributed to the variable acidity of the soil even on small areas. In a carefully controlled pot experiment with lucerne, the equivalent of a ton of lime per acre increased the yields upwards of three times, and a response to phosphate was only obtained in the presence of lime. In the later stages of the experiment, a response to molybdenum was obtained in the absence, but not in the presence, of lime.

(*d*) *Griffith Research Station, N.S.W.—Experiments on Irrigated Pastures.*—The objective of these trials is to compare the efficiency of water usage by winter growing pastures (irrigated in autumn and spring) with summer growing pastures (irrigated in spring, summer, and winter).

(1) Winter Pastures.—The two pastures under test are (i) *Phalaris tuberosa* and subterranean clover and (ii) Wimmera ryegrass and subterranean clover. The latter mixture has been more easily established than the former on the Hanwood loam at the Research Station. Results have shown that the earlier the commencement of the irrigations in autumn the greater are the yields and the more efficient the water usage. The earliest initial waterings were applied on March 1st, but even earlier initial irrigations may have given better results.

(2) Summer Pastures.—The two summer pastures are lucerne alone, and a mixture of perennial ryegrass, cocksfoot, and white clover. On the Hanwood loam, lucerne has proved easier to establish and has given consistently higher yields under irrigation than a pasture mixture of perennial ryegrass, cocksfoot, and white clover. The yield of lucerne depends primarily on temperature and is little increased by additional irrigation water. During the short term of the experiment—two summer periods—it is probable that the lucerne derived water from accumulated soil moisture, particularly in the earlier summer cuts. The lack of response of lucerne to the increased irrigations applied substantially agrees with results obtained by the Victorian Department of Agriculture at Werribee, where the optimal rate of watering is found to be 24 acre inches per annum. The minimum employed in the Griffith trials was 27 acre inches per annum.

(ii) *Plant Introduction.*

(*a*) *General.*—During the year, seed of vegetables, legumes, grasses, oil plants, and special wheats totalling 269 lots was introduced, making a grand total of 7,899 introductions of all kinds since 1930. Seed of 213 kinds was distributed in Australia, and 226 lots were sent abroad.

(*b*) *Tests at Canberra, A.C.T.*—A continuously wet spring succeeded by a very dry summer and autumn was not favourable to the establishment of grasses, but *Festuca Mairei, Agropyron cristatum, A. elongatum, A. intermedium, Bromus inermis, Phalaris stenoptera, Brachypodium phoenicoides,* and *Elymus junceus* gave good growth. *Festuca Mairei* and *Elymus junceus* were very palatable to sheep under free grazing. Among new seedlings, *Phalaris tuberosa* and *Dactylis glomerata* var. *hispanica* established best under the dry weather conditions. Of the introduced lucernes subjected to a four-year test, Hairy Peruvian and Argentine equalled Hunter River in yield, and Iraq No. 11 and Arizona Common were not far short.

(*c*) *Tests at Lawes, Southern Queensland.*—Seasonal conditions experienced at Lawes were again somewhat adverse, with heavy rains in October and December, followed by a very dry January-April period. Some germination failures and drowning-out resulted.

The green manure legumes *Dolichos lablab, Dolichos debilis, Mucuna* spp., *Phaseolus ricciardianus,* and especially *Vigna unguiculata,* made very vigorous and bulky growth on alluvial soil.

Various species and varieties of *Paspalum,* of which the "Kabulabula" strain of *Paspalum scrobiculatum* was considered the best, were the most promising grasses of the 1942-43 season. Other noteworthy strains were "Ruenya" and "Pungwe." *Paspalum laeve,* a good winter grass, showed up well at Lawes and on the Darling Downs. Initial grazing trials demonstrated the special palatability of the *Paspalum* species.

The relative effects of fertilizer topdressing, use of legumes, and inter-row cultivation on growth and vigour of perennial grasses were studied at Lawes, and the following preliminary conclusions were drawn:

(1) Under arid conditions, highest yields were obtained from established grasses intercultivated in three-foot rows; (2) grass yields from plots in which legumes and grasses were combined in swards did not exceed those from swards of grass alone; (3) under adequate rainfall, yields from swards topdressed with sulphate of ammonia greatly exceeded all others.

A grazing test of various grasses grown in half-acre plots demonstrated that *Paspalum scrobiculatum* is grazed by sheep more effectively and profitably than is Rhodes grass, on which grass the animals required supplementary feeding after ten days had passed.

At "Noorindoo," Maranoa, the annual legume *Phaseolus lathyroides,* which became established in Mitchell grass pasture, attracted favourable attention.

(*d*) *Tests at "Fitzroyvale," Central Queensland.*—The season was again rather unfavourable, excessive rains falling in the first half of February followed by two months without rain.

In swards of three years' duration, *Brachiaria brizantha, Melinis minutiflora,* and Kenya No. 1 Strain of Rhodes grass were outstanding, each yielding over 3 tons air-dried grass per acre per annum as compared with 2¼ tons from natural (spear grass) pasture. *Digitaria* strains yielded 4 tons per acre per annum of air-dried grass, 3¼ tons for the summer half-year and ¾ ton for the winter half-year. Residue measurements following grazing led to the conclusion that more frequent grazings in the summer are desirable, and that the shorter bite resulting therefrom is much to be preferred to the ranker growth. It was decided to subject all introductions to a cutting technique of 1, 2, 4, and 8 defoliations per annum. Two areas of natural pasture were subjected to similar treatment and samples for nitrogen determinations taken, to provide a norm for comparison. Strains of *Panicum maximum* proved no better in yield than natural pasture but very palatable. Some 22 strains are being systematically investigated. Periodic defoliation is also being applied to 7 strains of *Panicum coloratum,* 10 strains of *Urochloa* spp., 25 strains of *Digitaria* spp., and 7 strains of *Chloris gayana.*

Intercultivation of rows versus swards of *Brachiaria brizantha* trials indicated that there were no significant differences associated with row spacing, continuous versus dry-season cultivation, or listering, but that non-cultivated rows were definitely inferior to all other treatments.

Two strains of Jamnagar giant millet (*Pennisetum typhoideum*) from India and Kavirondo sorghum from Kenya have shown promise.

Legumes.—*Stylosanthes guianensis* proved a very suitable component of pasture mixtures, but frost at the Station eventually eliminated it from mixtures, thus showing that it is best fitted for a frost-free environment further north. Following elimination from pastures, the grass component of mixtures showed the beneficial residual effect of the incorporated legumes. Burning off and cultivating proved the best preparatory means of establishing this legume in natural pasture. The 1942-43 summer growth of Stylo was phenomenal. Field data and chemical analyses are expected to furnish significant figures on its yield and value in natural pasture, Everything points to the conclusion that this legume can be introduced into natural pasture by simple, inexpensive methods, a finding which is of practical value to relatively unimproved N.E. Australia. To bring about this improvement, it is necessary to test the legume in a more northerly frost-free environment, and eventually to produce seed in quantity in the Mackay-Townsville region.

Moist soil conditions are favourable to high germination results, but the use of a fungicide such as Ceresan was found advantageous under such conditions.

Yields of 20 to 25 bushels of seed per acre were obtained from pigeon pea (*Cajanus indicus*). One strain, "I.P. Type 24," from India yielded approximately 25 bushels per acre. This seed is the source of the "split pea" of commerce. The use of pigeon peas, either as a standing crop for grazing or as a whole-ground crop for trough feeding in the production of fat cattle, appears to be a sound proposition.

Other distinctly promising legumes are *Arachis nhambiquara, Vigna unguiculata, Dolichos biflorus,* and *Teramnus uncinatus*—all dense, decumbent to prostrate, effective in competing with weeds, and of distinct pasture value.

(*e*) *Tests at Muresk, Western Australia.*—During January, 1943, an officer of the Division was stationed at Muresk Agricultural College. Some 145 lots of seed, representing grasses, legumes, linseed, pyrethrum, guayule, and poppy, were sent from Canberra. For the time being the tests are being confined to Muresk, Harvey, and Merredin.

(iii) *Pasture Plant Improvement.*

(*a*) *At Canberra, A.C.T.*—Studies were continued on subterranean clover, lucerne, *Danthonia,* and annual medics.

Among subterranean clovers, the variety Tallarook continues growing later in the season than do the earlier varieties, but it does not make as much growth during the winter. However, another late variety called Wenigup is very vigorous during the winter and early spring, but does not re-establish well owing to relatively poor seed set. The two varieties have been crossed in expectation of breeding a late variety

combining winter vigour with good seed set. At Moss Vale, N.S.W., during the first year after establishment of a sward trial of lines selected from the Wenigup x Tallarook cross, one selection greatly outyielded Tallarook in the autumn, winter, and early spring, and at the same time produced an equal weight of seed per unit area. However, at Canberra, the same line did not re-establish as well as Tallarook. Further sward trials are in progress and selection for better seed yield is continuing. The selected lines are resistant to leaf rust disease. The Mt. Barker strain is susceptible to leaf rust, whilst Mulwala is resistant. Study of an F_2 population of a cross between these varieties indicates that resistance is inherited on a simple mendelian basis, susceptibility being dominant. Several resistant lines of the same maturity as Mt. Barker are being carried on for further selection.

A trial comprising 215 strains of lucerne, most of which were received from Lawes (Queensland), is being conducted at Dickson, with the object of selecting strains suitable for grazing for the Australian Capital Territory and southern Tablelands of New South Wales.

The breeding project with *Danthonia* has been continued. The object of this work is the production of vigorous perennial drought-resistant grasses for the drier parts of the wheat areas, particularly where soil erosion is a problem and where reduction of wheat production seems inevitable. A fairly large collection of species and strains has been built up during the last few years, and a programme of selection and seed increase is in operation.

The increase, provisionally in the Australian Capital Territory, of a number of lines of selected annual medics has been commenced, the aim of this undertaking being the ultimate supply of cheap seed in commercial quantities of legumes suitable for use in temporary pastures in cereal growing areas. This is desirable because of the need for rehabilitation of a large proportion of wheat lands and a more diversified agriculture in most of our areas of moderate rainfall.

An experiment was sown at Duntroon in the autumn of 1940 to determine the effect of adding lime, at the rate of one ton per acre at seeding, upon the subsequent growth of several legumes, including lucerne and subterranean clover. A cut made in 1942 showed that the average yield of legumes from the limed plots was more than twice as great as that from the unlimed.

(*b*) *At Lawes, Queensland.*—The investigations of lucerne as a pasture legume in southern Queensland have been continued. They have indicated that, apart from its nitrogen contribution, lucerne can provide considerable quantities of high protein pasturage in winter and spring if it is planted thinly in a grass sward. Of available material, Australian types still appear to be the best in so far as winter growth, total yield, and persistence under rotational grazing are concerned. However, an improvement in Australian types is possible in so far as they are susceptible to rust and other leaf diseases which cause considerable leaf fall and loss of nutritional value when matured lucerne is held over for subsequent grazing. With respect to rust it has been possible to select immune plants in other varieties, and it is now planned to transfer this immunity to Australian lucernes. A preliminary knowledge of the inheritance of rust immunity has already been obtained. So far as other leaf diseases are concerned, the position is more obscure as a number of diseases are of importance. Varying degrees of susceptibility to the major ones have been observed, and it is hoped that resistance may be obtained.

The investigations with Rhodes grass to determine and provide the most suitable strains for use in conjunction with lucerne have shown that a late maturing strain introduced from Kenya is promising. An experiment is being planned in collaboration with the Section of Agrostology to determine the relative merits of this and commercial strains, and also to measure the contribution of lucerne in swards of the two types.

Phalaris tuberosa progenies selected for persistence under Lawes conditions have shown a 30 per cent. increase in survival when compared with the best commercial strains. Although it does not appear that winter-growing perennial grasses are likely to assume great importance in this region except under irrigation conditions, this selected material should be of value in extending the area more suitable to *Phalaris* use. It will later be tested with this object in mind.

3. Weeds Investigations.

Owing to the shortage of staff, work on nutgrass, mintweed, and hoary cress has been discontinued.

Experiments on the control of galvanized burr (*Bassia Birchii*) in the St. George district in Queensland have been continued. The main experiment consists of a grazing trial in which an attempt is being made to control the burr by encouraging vigorous competition from native forage species through control of the stocking programme. After five years of controlled stocking, the burr had decreased to a negligible amount, even where grazing had been at the rate of a sheep to 2 acres. This has been attributed to the seasonal conditions during the course of the experiment. Heavy late summer rains resulted in a dense growth of grass which competed strongly with the burr, and dry conditions during winter and spring proved inimical to the development of the burr. More favourable conditions were experienced during the winter and spring of 1942, and even though there were good rains during the 1942-43 summer, the growth of grass failed to prevent a dense establishment of burr on all grazing treatments, except where stock have been excluded altogether. Thus it would appear at present that seasonal conditions, and not stocking, exert the controlling influence on the burr. In the experiments with poison sprays, although all chemicals tested proved effective in killing the plants to which they were applied, they did not prevent a re-establishment from seedlings when conditions became favourable during the winter of 1942.

4. Cereal Investigations.

(i) *Introductions.*—A number of imported wheats, barleys, and oats were subjected to test. V.50.3 wheat yielded at the rate of 50 bushels per acre as compared with 49 for Waratah; Flynn barley, apparently well suited by the climatic conditions obtaining, yielded at the high rate of 69 bushels per acre as against 54 for Trabut; and Mulga oats 83 bushels against Sunrise 71 bushels used as a check.

(ii) *Take-all.*—A three-year experiment on the effects of various agronomic practices on the incidence and control of take-all in a naturally infested field at Duntroon was completed this season. Continuous cropping with wheat resulted in 75 per cent. of take-all with a corresponding exceedingly low yield of grain. On the other hand, bare fallow for two years gave complete control of the disease and the highest yield (38 bushels per acre) of all the treatments. The results of the wheat-fallow-wheat rotation were 14 per cent. take-all but a good yield of grain (30 bushels per acre). Oats-fallow-wheat gave only 3 per cent. take-all, the yield of grain being 30 bushels per acre. Wheat following two years' lucerne produced a poor yield of grain, the amount of take-all

being 13 per cent. Wheat after two years of Wimmera rye gave an equally poor yield but only 3 per cent. take-all. Take-all in the wheat-oats-wheat rotation was 10 per cent., but the yield was 25 bushels per acre. Roots from the block that was fallowed for two years were completely free from lesions, whereas those from blocks treated otherwise were more or less diseased. The most severe root injury was in the block continuously cropped to wheat.

An experiment in the same field to test the pathogenicity of eight isolates derived from a single ascus of *Ophiobolus graminis* indicated that variations in pathogenicity of the isolates were significantly different for each form of inoculum, and the effectiveness of the inoculum varied with the plot.

Experimental work with 5-gallon drums of soil out of doors, at Black Mountain, was continued and extended. Using 18 drums per treatment, significant differences in the numbers of white-headed plants were obtained during the current year between the drums inoculated in 1941, the first year of the experiment, and those that were not inoculated. The number of white heads was greater in the latter. This apparently curious, but expected response, was due mainly to greater depletion of plant food by the more vigorous growth of the plants in the uninoculated drums during the previous year. Depletion of available plant food in fields cropped to wheat year after year therefore appears to be the logical explanation of the marked increase in take-all observed under such conditions. Plants growing in soil in which adequate amounts of plant food are available do not readily suffer from take-all.

White heads are, however, only an extreme expression of a disease that affects much larger numbers of plants somewhat less seriously. Other well known symptoms of take-all are rotted roots, smaller grain size, and a reduction of the total weight of grain and of the total weight of the plants. In the field, and also in the experiments here reported, these symptoms are much more common than white heads.

In the current year's experiments, very significant differences in the severity of root rotting were recorded, the worst being, as already observed for white heads, in the drums in which a good crop was obtained during the previous year. By the addition of rather large amounts of calcium sulphate or burnt lime to the soil, root rotting was almost altogether eliminated. The reason for the response to calcium sulphate is, however, not yet understood, its beneficial effects being only on the roots. Burnt lime makes available the plant food in the soil; this is reflected in the better growth of plants and greater grain yield than in the native soil.

In these experiments all but one of the elements necessary for adequate nutrition of plants were added to the soil in each series of drums in adequate amounts. The exception was nitrogen. Preliminary trials indicate, however, that the addition to the native soil of nitrates alone is not sufficient. A four-year experiment designed to elucidate this aspect of the problem is in progress.

5. Fruit Investigations.

(i) *In Tasmania.*—The investigations centered at Huonville dealing with storage disorders of apples and pears have been again reduced while work on problems more closely associated with war-time economy has been further extended. All experiments dealing with gas storage, the accumulation of carbon dioxide in storage chambers, and a number of projects concerned with the relation between the incidence of certain storage disorders in apples and pears and various orchard and storage conditions, have been temporarily discontinued.

The control of *internal cork* in apples by soil dressings of ½ lb. of borax per tree has continued for the seventh year since the application was made. This disorder has now been practically eliminated in Tasmania. *"Cork" of pears* has not responded to treatment by many chemicals applied as soil dressings and by injection. Grafting experiments to test the suggestion that this disorder is due to a virus are in progress. *"Dimple"* of Granny Smith and Cleopatra apples also has not responded to any chemical treatments nor has the past season's work given any further positive results as regards the causes of *dieback.* The differences in the keeping qualities of fruit of different varieties on different rootstocks previously reported were again evident.

Storage tests on apples treated with different types of surface coatings were continued. Certain varieties so treated held in excellent condition in cool store for more than nine months. During the 1942 season, 50,000 cases of apples were treated by a hand dipping machine at a commercial packing shed under the supervision and guidance of officers of the Council for the Apple and Pear Acquisition Committee. This fruit was held in common store with the loss of only 15 per cent., which was very low and indeed less than the loss in some cool stores. At the Huonville laboratory 9,000 cases were treated by an experimental coating machine, and information obtained on the relative value of different types of coating emulsions on semi-commercial scale lots of fruit. The coating method has certain limitations and some varieties give unsatisfactory results. The success of this method with other varieties has, however, been demonstrated.

The new problems investigated have concerned the dehydration of apples and potatoes, the vitamin C content of local fruits and fruit products, the sulphuring of evaporated apples, and new fruit products; they have been undertaken at the request of the Departments of Commerce and Agriculture, and Supply and Shipping. A considerable amount of technical assistance has also been given to managements handling the processing of fruit and vegetables.

An experimental rotary-louvre dryer was constructed at the Huonville laboratory, and data on the value of this type of dryer as compared with the tunnel and kiln methods for apples and potatoes were obtained. Experiments on different methods of sulphuring and resulphuring evaporated apples have given satisfactory results. The methods previously in use were not efficient, and under-sulphuring resulted in poor keeping quality of the pack in hot climates. The information collected on the vitamin C content of Tasmanian fruits and fruit products has been of considerable value in ensuring the most efficient use of the processed fruit packs. Technical advice and assistance to manufacturers regarding methods of processing have also substantially increased the vitamin C content of local fruit and vegetable products.

(ii) *At Stanthorpe, Queensland.*—The investigations of the problems of apple and pear rootstocks at Stanthorpe have been reduced to a minimum consistent with the continuance of the major, long-term, experiments. No more apple rootstocks have been propagated in stools or layer beds, but the 6-acre rootstock trial plot planted in 1938 has been maintained. In addition, several minor items have received attention as opportunity allowed. These included further observations on the nature of the root systems of scion varieties grown on their own roots. The only commercial variety grown in the Stanthorpe district which develops a strong, even root system when grown on its own roots is Delicious. Both Granny Smith and Gravenstein

develop poor root systems, and that of the latter variety is also shallow and uneven. Of other varieties examined, Commerce and Red Statesman developed vigorous root systems while Dunns and Williams Favourite showed poor root vigour. A disease, probably identical with "apple measles," occurred on Jonathan and Delicious trees in the main experiment trial during 1941-42. Preliminary evidence has been obtained that the application of boron corrected this condition.

Layer beds of a series of pear rootstocks, collected with the assistance and co-operation of the Victorian Department of Agriculture from outstanding trees in the pear districts of that State, have been established. Only one of these selections has so far been further propagated. It shows promise of being a good rooting stock, and a few budded to Williams appear to be compatible with that variety.

(iii) *At Griffith.*—Investigations have been continued at the Irrigation Research Station, Griffith, on rootstocks and shoot and root growth of citrus.

(*a*) *Rootstocks.*—Many factors undoubtedly contribute to the unthriftiness and early decline of citrus groves in the Murrumbidgee Area. Waterlogging of the soil, especially during winter, is especially destructive under certain conditions of surface contour and on particular soil types. The use of unsuitable stock types is probably a factor which predisposes the trees to damage under these conditions and materially contributes to the early decline of many groves. Work in progress aims at finding a series of rootstocks compatible with the main commercial citrus varieties and suited to the various soil conditions that prevail on the Murrumbidgee and Lower Murray irrigation areas. Further collections of root cuttings from old trees of outstanding vigour and performance in the Mildura area and coastal districts of New South Wales were made during the season. Collections were made from 43 trees comprising types of sweet orange, lemon, Seville orange, mandarin, and *Poncirus trifoliata.* Rooted plants from 21 types were successfully raised. Trees raised from root cuttings collected from outstanding trees in the Murrumbidgee Area itself during the previous season have been planted in a nursery trial.

No germination of seed of rootstock types imported from overseas this season was obtained. Two nursery trials of various rootstocks obtained from imported seed and locally selected seed are in progress. The first trial planted in 1940 includes seven rootstock types. These were budded with navels and Valencias during the spring of 1942 and so far all have proved compatible with both scion varieties. The second trial was planted in 1942 and contains 15 rootstocks, including four rough lemon types, three Seville orange, two citron, a Tangelo, and *Poncirus trifoliata.*

Very considerable difference in the vigour and growth of these types are already apparent.

Following the discovery by officers of the N.S.W. Department of Agriculture that a disease caused by the fungus *Phytophthora citrophthora* severely damaged the root systems of citrus trees, particularly under conditions where excess soil water and high watertables obtained, trials of the susceptibility of different rootstocks to this disease were made. All lemon and sweet orange types proved to be very susceptible; Seville types were fairly susceptible and *Poncirus trifoliata* practically resistant. The *Poncirus trifoliata* stock commonly used as a rootstock in Australia is very inconsistent in its behaviour, especially when budded to navel oranges. Very frequently the trees are dwarfed in this stock. Selection of *trifoliata* types which produce vigorous growth in the scion variety is in progress.

(*b*) *Growth Studies.*—The method of assessing the changes in growth, health, and vigour of experiment trees by periodic surveys has continued to be applied to all experiment plots at the Research Stations. The progressive effects of various treatments are made apparent by these surveys before any appreciable differences in yield of fruit can be measured. These results are recorded under the section of this report dealing with the investigations of the Irrigation Research Station, Griffith.

The studies made of citrus root growth during the season by means of the observation trench showed again that the period of active root growth did not commence until late November and ceased early in March. The result of weekly samplings over a period of two years has shown that the root activity of lemon stock is at a minimum during July-October Comparative studies of the root growth of sweet orange, sour orange, and *trifoliata* stocks are in progress. Further information has been obtained respecting the distribution of the roots of lemon stock in different soil types.

The inarching experiments described in the reports for 1939-40 and 1940-41 have failed to show any effect of this treatment upon tree growth or health.

6. Drug Plant Investigations.

The Department of Pharmacy, University of Sydney, and the Department of Physiology, University of Melbourne, have continued to carry out the analysis and testing of material in connection with the drug plant investigations and have been responsible for the investigation of methods of drug extraction. The Departments of Agriculture of the various States and the Sub-Department of Forestry, Queensland, have also continued to co-operate in the conduct of field experiment plots of the different drug plants.

(i) *Hyoscine and Atropine.*—Suitable methods for the extraction of hyoscyamine from the native corkwood tree (*Duboisia myoporoides*) growing in the Gosford area and southwards thereof in New South Wales, and for the conversion of the hyoscyamine into atropine have been determined. The same processes are satisfactory for the manufacture of atropine from the leaf of *Duboisia Leichhardtii.* This species seems to be a better source of atropine than southern *D. myoporoides,* but a survey has shown that natural stands are limited in extent. Commercial cultivation is highly desirable.

A considerable difference still exists between laboratory assay and actual yield of alkaloid obtained on a commercial scale from *Duboisia* leaf. Further investigation of methods of extraction have been temporarily suspended, however, because the manufacture of both hyoscine and atropine is now on a reasonably satisfactory basis.

A start has been made to select from naturally occurring stands types of *Duboisia* which produce the highest percentage of alkaloid. Assays for total alkaloid have been completed on some 70 individual tree samples. Experiments have also been started to determine the most effective and economic methods of cultivation, and to study such items as methods of propagation, pest incidence and control, and time and frequency of harvest. Seed of *Atropa belladonna* and *Hyoscyamus niger* has been distributed to growers intending to produce material of these plants for the manufacture of galenical preparations containing hyoscine and hyoscyamine.

(ii) *Opium Alkaloids.*—The colorimetric method used in the laboratory for estimating the percentage of morphine present in experimental samples of opium poppy (*Papaver somniferum*) material during the 1940-41 and 1941-42 seasons, has been found

inadequate. Attention has therefore been given to the development of a satisfactory method of extracting the morphine from small samples. Good progress has been made.

Experimental plots grown during the season at Canberra were designed to obtain further information on the question of time of harvest and the relative value of different varieties. Assay results are not yet available.

The larger areas grown under the supervision of the Council for the production of raw material for the manufacture of opium alkaloids were moderately successful. The main crop losses experienced were on an irrigation area where waterlogging of the soil occurred as a result of excessive rains during the winter. Autumn sowings were made again this year on a commercial scale under the Council's supervision

(iii) *Ephedrine.* — Analysis of material of the plants of *Ephedra gerardiana, E. intermedia,* and *E. nebrodensis* established at Canberra during March, 1941, was made during February, 1943. The alkaloid contents were: 1.35 per cent. (*gerardiana*); 1.05 per cent. and 0.58 per cent. (*intermedia,* two types); and 0.98 per cent. (*nebrodensis*). Assays of material collected at different seasons are in progress. The most vegetative growth was made by *gerardiana* and the least by *nebrodensis.* One ½ lb. of seed of *E. gerardiana* was harvested. The experiment plots now contain some 4,600 plants, and 7,000 seedlings of *E. gerardiana* have been raised for planting during the coming season.

(iv) *Quinine.*—The establishment of small experiment plots of *Cinchona* has been effected successfully at only one location. These plots established in Queensland by the Sub-Department of Forestry, comprise approximately 1,000 trees just over two years old.

(v) *Emetine.* — Some 600 plants of *Caephelis ipecacuanha* have been established in Queensland. Assay of the roots has revealed a satisfactory alkaloid content of 2.5 per cent.

(vi) *Santonin.*—The propagation of *Artemisia* has been continued. Approximately 3,000 plants are at present established, and it is proposed to extend the plots by 5,000 plants during the coming season.

(vii) *Other Drugs.*—Small lots of squill (*Urginea Scilla*), buchu (*Barosma* spp.), colchicum (*Colchicum autumnale*), dill, aniseed, angelica, coriander, grindelia, and *Digitalis,* are being grown for the production of seed and propagating material.

(viii) *Native Plants as Sources of Medicinal Drugs.*—A species of *Erythroxylon,* native to Queensland, has been found to contain tropacaine.

(ix) *Pyrethrum.*—The plot (3 square chains) of *Pyrethrum cinerarifolium* at Canberra yielded at the rate of 12 cwt. of dried flowers per acre during its second season of growth. 200 lb. of seed was harvested and this seed has been used in establishing larger areas for production. Some 25 clonal types have been obtained from the Canberra plants. Very considerable differences in vegetative growth and habit and pyrethrin content is apparent between the various types. Work aimed at selecting the best of these for further propagation is in progress.

7. Tobacco Investigations.

(i) *Diseases.*—Further work with the jassid *T. argentata,* a vector of yellow dwarf of tobacco, has shown that this insect is also a vector of big bud, a virus disease of tobacco and tomato. Many other species of plant are also affected. The disease was transmitted by insects to 24 species in 12 families, and symptoms similar to those obtained by insect transmission were observed occurring naturally on 65 species, many of them being common garden plants, in 24 families. Greening of floral parts is characteristic of the disease, therefore "virescence" is considered a more appropriate name than "big bud."

(ii) *Quality.*—Work on grade standards for Australian-grown flue-cured tobacco was continued. A system of grades was submitted to, and approved by, a conference of tobacco technical officers of the Council and States. The proposals were then circulated to tobacco-growers' organisations and to manufacturers for comments and suggestions for improvement. The basic subdivision of leaf according to stalk position is already being used by manufacturers. A practical test of the proposed system is being made on a farm in Victoria.

8. Vegetable Fibres.

(i) *Flax.*—At Canberra, 16 different varieties of strains were grown in randomized blocks. Early growth was very satisfactory, but subsequently waterlogging caused such variability between plots that reliable comparisons of varieties could not be obtained. In a rate of sowing trial, using the varieties Stormont Gossamer and Stormont Cirrus at rates of 70, 90, 110, and 130 lb. per acre, there were no significant differences in yield, but number of plants per plot increased with increased rates of sowing.

The morphological studies at Sydney University were continued and the data are being examined statistically.

(*a*) *Retting.*—Satisfactory progress has been made in the study of methods of retting flax. In the course of experiments aimed at evolving alternative methods, fibre was produced that was very favourably reported on by local spinners. One of the controlling factors has been applied in several small-scale experiments in ordinary warm and cold water rets with good results. It is now being tried in commercial retting tanks.

(*b*) *Diseases.*—With the exception of rust which caused more than usual loss in Tasmania during this season, the main diseases of flax are apparently due to physiological trouble. One of them, known here as die-back, is associated with waterlogging near flowering time, the other, browning, is of economic importance only on some peaty soils. The organism, *Pullularia pullulans,* that is associated with the browned areas can be isolated with equal facility from healthy harvested straws that have been kept moist for about 24 hours. It is one of the commonest retting organisms under our conditions.

(ii) *Other Fibre Plants.*—The fibre plant, *Urena lobata,* a jute substitute, occurs naturally in the coastal regions of North Queensland, but there appears to be little prospect of its development economically. A similar position occurs with a number of other plants known to contain fibre, some of which have received attention during the year.

9. Potato Investigations.

(i) *Breeding.* — The programme aimed at the development of varieties resistant to viruses A, X, Y, and leaf-roll has been continued. The most promising results have been achieved in obtaining cross-bred seedlings with resistance to virus Y. The technique of raising seedlings has been worked out, and methods of testing for virus resistance are being established.

(ii) *Potato Stocks Free from Virus X.*—In addition to the two varieties, Up-to-Date and Bismarck, of which virus-free stocks have been obtained, there is now a third variety, the Victorian Snowflake, of which a few virus-free tubers are available for multiplication. The Up-to-Date stocks include tuberlines of varying maturity; they are being maintained

as tuber-lines during multiplication. With the aid of the N.S.W. and Tasmanian Departments of Agriculture and the Lawes Agricultural College (Q.), a winter and summer crop were grown, and, considering the exceedingly unfavourable seasonal conditions, satisfactory yields were obtained.

The dry conditions under which the summer crop in New South Wales was grown tested the drought resistance of the Up-to-Date stocks, and showed that it was superior to that of certified stocks of Up-to-Date containing virus X.

The virus-free Bismarck is producing plants of exceptional vigour, and selected virus-free stocks of the American variety Sebago promise high yields and excellent quality under Australian conditions. The multiplication of these stocks is proceeding, and efforts are being made to arrange for the permanent maintenance of parent stocks in a virus-free condition.

(iii) *Transmission of Potato Viruses.*—Much basic work has been done in establishing sampling methods for estimating and studying the total populations of the aphid-vectors of virus as in potato crops. This has involved measurements of the leaf area of whole plots of potato plants; a workable rating method has been devised which gives results accurate to a few per cent. The growth of the potato foliage has been followed during the vegetative stage of development, and different varieties have shown an unexpected similarity until the inception of flowering, particularly in the growth of the main shoots.

The differences in leaf area of different strains and varieties depend largely on the growth rates of axillary shoots: in early maturing types the axillary growth is relatively slow and ceases early. The new methods of estimating leaf area and the information they have provided about methods of sampling aphid populations are being applied in the investigations of such practical problems as the relative importance of winged and wingless aphids in the transmission of leaf-roll in the field. Combined with the aphid work has been an investigation of susceptibility to leaf-roll of the commoner Australian varieties of potato. Preliminary results suggest that differences in susceptibility are a function of the plant tissues and are not merely due to preferential feeding by aphids.

(iv) *Strain Mixtures of Virus X.*—By testing many tubers of several varieties for their content of virus X, it was discovered that different lots of the same variety carried strain mixtures of the same average severity. Some varieties carried severer strains than others. Apparently, the susceptibility of the variety largely determines the proportion of strains in the mixtures of virus X normally present in plants and tubers. This has a bearing on the selection and maintenance of seed stocks containing mixtures of virus X, consisting predominantly of mild strains, and therefore potentially capable of higher yields than ordinary stocks.

10. Vegetable and Vegetable Seed Investigations.

At the Dickson Experiment Station, 10 acres provided with spray irrigation facilities are being used for vegetable and vegetable seed work. In co-operation with the Institute of Anatomy, the nutritive values of vegetables grown at the Station are being examined. Investigations completed and in progress cover the following:—

(i) *Carrot.*—An attempt is being made to evolve cheaper methods of seed production with this crop. In this connection, time of planting of the seed, time of transplanting of the roots, and "seed to seed" practices are being considered.

(ii) *Red Beet.*—This has responded particularly well to the "seed to seed" method which has given good seed yields from a planting as late at May in the Canberra environment. Red beet has proved to be very susceptible to the low lime and boron status of the Canberra soil. Boron deficiency manifested itself in some red beet seed plots by a proliferation and premature browning of the flowers, an occurrence which greatly depressed yields.

(iii) *Cabbage.*—(*a*) The effect of time of planting, removal of the head, and seeding through the head on the yield and quality of cabbage seed is being investigated. (*b*) A line of cabbage which shows decided resistance to attack by the common insect pests of the cabbage is being developed. (*c*) Some of the common cabbage varieties grown in Australia show considerable genetic variability unless grown under most favourable conditions which tend to mask the variations. With this in mind, further selection for uniformity of type is being done.

(iv) *Swede.*—At the Dickson Experiment Station a yield of 476 lb. per acre of good quality Purple Top swede seed was produced in an experiment in seed to seed production during April to December, 1942. In a subsidiary experiment it was shown that thinning to 6 inches or 12 inches between plants had no significant effect on yield, and little effect on average seed weight.

(v) *Tomato.*—(*a*) *Spotted Wilt.*—Following work on the transmission of the spotted wilt virus through potato tubers it has been demonstrated that this virus is normally a complex of at least three strains that have been called mild, ringspot, and necrotic. The necrotic strain appears identical with the American tip-blight virus first described in Oregon. Different combinations of the three strains of the virus cause a wide variety of symptoms. This helps to explain the variability of the spotted wilt disease which has puzzled so many workers.

(*b*) *Varieties.*—A preliminary trial of 24 tomato varieties commonly grown in Australia demonstrated the need for the elimination of unsuitable varieties and the introduction or development of varieties more suited to the demands created by the war. A critical test is to be made of new and promising varieties from overseas in comparison with the present standard varieties used in Australia.

(*c*) *Seed.*—Tomato seed extraction has not been carried out extensively in Australia. The present cumbersome and time-consuming fermentation method does not encourage large scale tomato seed extraction. At Canberra, a new and simple method has been evolved which makes seed extraction practically a continuous process. It depends on the rapid dispersion of the gelatinous seed sacs in freshly pulped tomatoes by the addition of commercial hydrochloric acid at the rate of 2 gallons per ton of pulp. The seed can be washed within an hour by the usual method. In this way the time-consuming fermentation of 24-48 hours is eliminated so that tomato seed production can be concentrated in large areas which would be impossible to handle by the old method. Large scale commercial trials have proved the value and cheapness of the new method, and have demonstrated that cucumbers can be handled in the same way except that acid needs to be added at the rate of 3 gallons per ton of crushed cucumbers.

(vi) *Lettuce.*—(*a*) *"Slimy Heart."*—The development of this in lettuce seed crops has proved to be one of the worst difficulties encountered in lettuce seed production. Measures for the elimination of this trouble based on time of planting and method of irrigation are being investigated.

(*b*) *Varieties.*—Lettuce variety trials have demonstrated the value of the Imperial lettuces, particularly Imperial D, Imperial 44, and Imperial 847.

(vii) *Peas.*—(*a*) *Pea Mosaic Virus.*—To determine the economic significance of this virus on pea seed production in Australia, a comprehensive field experiment was made in Canberra. Using the commonest Australian variety, Greenfeast, comparison was made of the yield of healthy plants, plants infected from a very early stage, and plants infected late in the season. It was found that the reduction in yield of plants infected very early was only about 17 per cent. and the yield of late-infected plants was not reduced significantly. In the variety Greenfeast, an average field infection with mosaic would be commercially insignificant. Conditions for the rapid dissemination of pea-mosaic virus are normally absent in Australia, but in local, badly affected areas, the use of an immune variety such as William Massey should reduce loss.

(*b*) *Varieties.*—Much confusion exists in Australia as to the characteristics and naming of pea varieties. This is due to the introduction of a comparatively large number of new varieties which are being used for canning programmes. A trial of varieties used in Australia is in progress to determine particularly their genetic characteristics so that classification can be placed on a more definite basis.

(viii) *Beans.*—(*a*) *Mosaic.*—Seed samples of the variety Brown Beauty produced in various districts of Australia are being grown to determine the importance of the virus disease bean mosaic.

(*b*) *Varieties.*—A large number of bean varieties new to Australia have been introduced, particularly from U.S.A., with the object of testing their suitability to Australian conditions. These are being grown at Canberra and at Merbein in the Murray Valley. Those which show promise will be increased and distributed.

(ix) *New Vegetables.*—Several new vegetables have been introduced during the year, and among them are Burpee's "Celtuce," Lima bean varieties, "Pimiento" pepper, *Fusarium*-resisting "Pan-America" tomato, and cantaloupes resistant to powdery mildew.

(x) *Seed Quality Trials.*—The value of vegetable seed is dependent on the type of vegetable. In order to demonstrate whether Australian vegetable seed grown along the right lines is the equal of imported seed the quality of vegetables grown from Australian and imported seed is being compared.

(xi) *Vegetable Seeds Production.*—The programme of vegetable seeds production is the responsibility of the Commonwealth Vegetable Seeds Committee operating under the Department of Commerce and Agriculture. It is sufficient to state here that many difficulties of local production, caused by shortage of labour, supplies, and experience, and in importing to augment supplies, had to be surmounted.

11. Rubber Plants Investigations.

(i) *General.*—Hundreds of different kinds of plants contain caoutchouc, with or without resins, and, with some exceptions, this rubber substance is found in the latex. The main sources of supply for the world were the plantations of Ceylon, Malaya, Netherlands East Indies, Burma, Indo-China, Borneo, Thailand, and India, which plantations produced 1,000,000 tons of rubber per annum. The loss of most of these sources of supply has directed attention to other lesser known and actually less productive sources. There are in Australia, particularly in the northern half of the continent and more particularly in Queensland, many plants both indigenous and exotic, which contain some caoutchouc. Out of the many available plants, present investigations are chiefly concerned with three—*Cryptostegia*, guayule, and *Taraxacum*.

(ii) *Cryptostegia.*—This introduced vine has become established, mainly along watercourses in the vicinity of Charters Towers northwards in Queensland. It is in scattered stands and in country not too conducive to easy harvesting procedure. It is a possible emergency source of rubber if it can be grown as a crop, thereby facilitating harvesting and milling operations. The possibilities are being investigated, with the field work in the hands of the Queensland Department of Agriculture and Stock, and the work on rubber extraction under the general supervision of Mr. W. A. Furnell, rubber technologist of the Department of Supply and Shipping.

(iii) *Guayule.*—The Division introduced this plant from California in 1931, and most of the original plants are still growing in the introduction area on the Council's plots at Black Mountain, Canberra. Seed from these was saved each year and was thus available for immediate trial plantings in selected areas. For most of these trials the Waite Agricultural Research Institute has been responsible, the Council providing seed and 3,000 transplants. Specially selected seed has been grown by the Waite Institute and the Council for permanent plantings in those areas where success is evidently to be expected, at present mainly in South Australia. At the Dickson Experiment Station in Canberra, an area is planted which will not be harvested for rubber, but which will remain as a source of mother seed. The Department of the Interior also granted the use of an area of nursery in the Parks and Gardens nursery at Yarralumla for raising seedlings.

(iv) *Taraxacum.*—In the U.S.S.R., special attention has been paid to a number of plants among which members of the dandelion group have attracted most favourable attention, more particularly *Taraxacum Koksaghyz* and *T. megaliarhizon.* Rubber in the latter is reputed to be as good as that in *Hevea brasiliensis*, but the content is less than in *Taraxacum Koksaghyz.* By courtesy of the U.S.S.R. Government, seed of "Koksaghyz" was sent to the Council and tests of this plant under field conditions and in pot cultures were commenced in August, 1942. Spring and autumn seedlings in the field have established very poorly at Canberra because of the lack of vigour in germination and of the seedlings. Under pot conditions the plant establishes slowly but satisfactorily, and marked responses to lime and phosphates have been recorded but none to nitrogenous fertilizers. A peculiarity of the plants under greenhouse conditions is that they enter a dormant stage twice during the summer period, a proportion failing to make regrowth. This dormant stage does not appear to be related with moisture, temperature, or length of day.

Preliminary analyses for rubber content indicate that the percentage of rubber is of the same order as that obtained in U.S.S.R. The roots are small and high yields per acre cannot be anticipated. Tests on the seed germination, establishment, and yield of rubber are being continued. Preliminary field trials are being made in each State by the respective Departments of Agriculture.

12. Other Investigations.

(i) *Citric Acid Production.*—Preliminary investigations were undertaken to find a high yielding citric-acid producing fungus and to determine whether the acid could be produced from wheat by

fungal fermentation. Twenty-three isolates of different fungi, including species of *Aspergillus penicillium* and *Trichoderma,* were first tested for acid production on various carbon sources and then for citric acid production. Of these isolates, only three proved to be acid producers under the conditions of the standard test. One of them produced very high titratable acidity when glucose or sucrose was the carbon source, but the yield of citric acid was only 4 per cent. of the total carbon. From this it seems that a very large number of strains of suitable fungi will have to be tested in order to find a strain that will produce a high yield. Citric acid production from wheat grain was demonstrated as a result of two fermentation processes, saccharification of steamed grain with *Mucor racemosus* followed by acidification with weak sulphuric acid and fermentation with *Aspergillus niger.*

(ii) *Herbarium.* — Determinations of pasture plants of Queensland and the Northern Territory were made from collections made during the year. The final stages of the compilation of lists of standardized common names of the more important Australian grasses, other pasture plants, and weeds was reached during the year and the results published in Bulletin 156 of the Council's series.

III. ENTOMOLOGICAL INVESTIGATIONS.

1. General.

Emphasis continues to be placed on entomological work of special importance under war-time conditions. Investigations on medical entomology carried out in the interests of the medical branches of the fighting Services have been gratifyingly productive. The study of the insect pests of stored wheat and wool has been continued and has produced results of practical importance at the present time. More intensive work on the insect pests of vegetables is now in progress. The investigation of the locust problem continues to progress in spite of adverse circumstances. Parasites of several important pests have been successfully introduced into Australia and some of these have already become established in the field. Insect enemies of noxious weeds introduced some years ago have produced particularly promising effects in the field during the past season. A decidedly improved blowfly dressing has been evolved, and other advances have been made with insecticides. Owing to the spread of the buffalo-fly to the coastal regions of northern Queensland, it has been found necessary to take up the investigation of this pest again, this time in a new environment. Arrangements have been made to increase the scope of the cattle tick investigations and to intensify them.

2. Insect Pests of Stored Wheat.

(i) *General.*—The problem of combating insect pests in stored grain has been made more difficult owing to the war-time shortage of labour, materials, and transport facilities. Investigation of the problems as they arise in storage depots and other places, supplemented by laboratory studies, are being continued.

(ii) *Bulk Depots.* — A system of bulk wheat storage, similar to that developed in Western Australia, has been introduced into Victoria, millions of bushels of wheat being stored in a single mound in an enormous shed. Observations made on one of these over a period of nine months show that the moisture content, initially 9.8 per cent., remained practically unchanged, except for regular seasonal fluctuations in the top few inches of wheat near the surface of the mound. There is also a seasonal fluctuation in temperature affecting at least the top nine feet of grain, the degree of fluctuation being greatest near the surface, where it is also influenced by diurnal temperature changes. No appreciable general increase in temperature occurred in the lower masses of grain.

These physical conditions have obviously determined the nature of the insect infestation. The low moisture-contents have considerably limited the development of the rice and granary weevil which are comparatively rare. *Rhizopertha dominica,* on the other hand, has increased rapidly on the northern slope and on the apex of the mound, and this insect raised the wheat temperature to about 103° F. at a depth of one foot (a temperature much above its optimum), and even at a depth of nine feet the temperature is appreciably increased. In the heavily infested pockets, *Rhizopertha* occurs principally in the top foot of wheat and is not found at a depth greater than 2 ft. 6 in. It is clear that the restriction of the insects to the surface is not, in this instance, attributable to temperature, and the possibility of a carbon dioxide build-up in the wheat is being investigated. Preliminary work has shown that some degree of such build-up occurs. The principal secondary pests in Victorian bulk wheat are *Silvanus surinamensis* and *Tribolium castaneum. T. confusum* is rare, though this insect appears to be far more common than *T. castaneum* in Victorian flour mills.

(iii) *Control Measures in Bulk Depots.* — The virtual restriction of insect pests to the top few feet of wheat in bulk depots considerably simplifies the problem of control measures. Sprinkling the surface of infested areas with carbon bisulphide, at a dosage of 12 fluid ounces per square yard, and covering with a tarpaulin for 24 hours, gave an adult kill of about 95 per cent. Large scale experiments are in progress, in which inert dusts (dolomite and magnesite) are spread at different dosages on the wheat surface, the dust being raked into some plots and left on the surfaces of others. Areas heavily infested by *Rhizopertha* are treated with carbon bisulphide before the dust is applied.

(iv) *Fumigation of Bag-Stacks.* — A series of experiments which aim at finding a simple method by which weevily commercial bag-stacks can be effectively fumigated with carbon bisulphide are in progress. A method of fumigating large quantities of bagged wheat has been devised, but it is hoped to simplify the technique. A dosage of one gallon per 1,000 cub. ft. gave an apparent 100 per cent. kill of weevil, in 18 hours, when stacks were dismantled and sampled. The experiments were carried out on stacks of 2,050–2,800 bags, but the method could be applied to stacks of any reasonable size. Experiment showed that it is not feasible to fumigate an infested portion of a large stack effectively with carbon bisulphide by placing an air-tight enclosure at the front, back, and roof of the infested part. The rate of diffusion from the fumigated section was so great that no apparent kill was obtained at a dosage of 1½ gallons per 1,000 cub. ft.

(v) *Stack-Site Sterilization.* — Several fortified and unfortified mineral oil emulsions have been tested as contact insecticides against weevils in the laboratory. These tests have confirmed the view that the addition of a toxic agent to the oil is desirable and have also shown that the most satisfactory spray material for general use is a proprietary mineral oil emulsion containing nitrated phenols. In the course of testing some Australian nitrated cresols, it was found that a mineral oil emulsion containing 5 per cent. commercial grade dinitro-o-cresol possessed a toxicity comparable to that of the proprietary emulsion.

(vi) *Bag Dipping.* — Contact spray insecticides of the type used for stack site sterilization can be used for treating bags suspected of harbouring grain weevils. Tests have shown that either the above above-mentioned proprietary oil emulsion containing nitrated phenols, or a proprietary creosote emulsion, is satisfactory for the purpose. The most satisfactory results are obtained by dipping the bags for two minutes and then stacking them wet for two days before drying. It has also been found that the effectiveness of bag dipping improves as the environmental temperature increases.

(vii) *Treatment with "Inert" Mineral Dusts.*— Because of renewed interest in the use of mineral dusts for the protection of stored wheat, further tests have been made with these materials. A comparative test with magnesite, which is probably the most effective dust of Australian origin, enabled the various grain insects to be classified in descending order of susceptibility as follows:—*Laemophloeus minutus, Oryzaephilus surinamensis, Calandra oryzae, C. granaria, Tribolium castaneum,* and *Rhizopertha dominica.*

Three samples of shell grits from Victorian sources were tested. The effectiveness of these materials was roughly proportional to their silica contents, and all were inferior to dolomite and magnesite against both *C. oryzae* and *R. dominica.* The use of dust barriers to trap migrating grain insects was investigated under laboratory conditions. The results indicate that barriers 1 ft. wide offer a very effective means of checking crawling infestation.

One disadvantage of the dust treatment of wheat is the impairing of the free running character of normal grain. Measurements of the angle of repose of dusted and undusted grain showed that this angle may be 8–10° steeper with wheat containing 0.1–0.75 per cent. dust than with undusted wheat.

(viii) *Self-gassing by Carbon Dioxide.* — Self-gassing of grain insects by utilizing the carbon dioxide produced by their metabolism has occasionally been used for the control of insect infestation A study of the production of carbon dioxide by populations of *R. dominica* in columns of wheat is in progress, and variables such as time, population density, temperature, and wheat moisture content are being investigated. This investigation is far from complete, but it has already shown that populations of the order found in the field can build up heavy concentrations of carbon dioxide very quickly.

(ix) *Baking Quality of Treated Wheat.*—In the earlier stages of the carbon-bisulphide fumigation work, dosages up to three gallons per 1,000 cub. ft. were used, and it was reported that the fumigation had caused considerable deterioration in the baking quality of the resultant flour which, however, gradually improved on storage. Samples taken from a stack successfully fumigated at one gallon per 1,000 cub. ft. were submitted for baking tests, but no appreciable diminution in baking quality was disclosed. This result needs confirmation, since the wheat used happened to be of particularly poor quality.

The effect of prolonged storage at high temperature on the baking quality of wheat is being studied in collaboration with the William Angliss Food Trades School. Wheat held at 9 per cent. and 10 per cent. moisture content at temperatures of 70°, 90° and 105° F. is to be submitted to baking tests at 3, 6, 9, and 12 months. The first baking tests, made after three months' storage, showed that over this period none of the wheat suffered any deterioration.

(x) *Biology of Wheat-Infesting Insects.*—Biological studies have been restricted almost entirely to *Rhizopertha dominica.* The lower temperature limit for the development of this species has not yet been determined, but it apparently lies slightly below 70° F., since at this temperature breeding does take place although very slowly. At high temperatures (90°–110° F.) the effects of different relative humidities, and therefore of different moisture contents of wheat, on development are still being investigated. Results so far indicate that increase in moisture content is accompanied by an increase in the upper limit of developmental temperature, so that at 8.5 per cent. moisture content the upper limit of development appears to be 92° F., whereas at 10.5 per cent. moisture content it is 100° F. As yet no development has been recorded at temperatures above 100° F., although viable eggs have been laid at 108° F. on wheat of 12 per cent. moisture content.

Preliminary studies on the biology of the flat grain beetle, *Laemophloeus minutus,* have shown that this insect breeds successfully on whole wheat, broken wheat, and pollard; it can just maintain itself on bran and is unable to increase on white flour or reduction flour. The life cycle occupies approximately 28 days at 90° F., 40–50 days at 80° F., and 80–100 days at 70° F.

Studies of the weight loss caused by adults of *Rhizopertha dominica, Calandra granaria,* and *C. oryzae* over a range of temperatures showed that the maximum weight loss per week by *R. dominica* was twice its own weight at 95° F., *C. oryzae* 1.25 times its own weight at 90° F., and *C. granaria* 1.25 times its own weight at 80° F.

3. Insect Pests of Stored Wool.

(i) *General.*—Although infestation of stored wool by clothes moths has become noticeably worse, both in Brisbane and Sydney, than it was when investigation of this problem was commenced in December, 1941, it has fortunately not increased to the extent that was thought possible. Quite large numbers of *Apanteles carpatus,* a parasite of the clothes moth *Tineola biselliella,* are present in the wool stores, and must be at least partly responsible for limiting the increase of the moths. During the autumn a tremendous fall was recorded in the number of moths caught on a large tanglefoot trap in one of the Brisbane stores. This fall cannot be explained on the basis of a fall in temperature, and it is being investigated further.

(ii) *Fumigation Experiments.*—Laboratory experiments were carried out with the object of making a preliminary selection from among a number of materials that suggested themselves for use as sprays or solid fumigants against infested stacks. The results showed that diesoline had very little fumigation power. Solvent naphtha, ortho-dichlorbenzene, and para-dichlorbenzene had high initial toxicity, but this was lost completely after seven weeks in the case of the first two, and after nine weeks in the case of the third. Creosote and cresylic acid were both toxic and fairly persistent, but the former stains wool, and the latter has very objectionable fumes when used neat or in high concentration. Naphthalene was strongly toxic, producing a nearly complete kill after one week's exposure, and also persisted with undiminished toxicity for more than six months, by when almost all the crystals had evaporated; a rapid drop in toxicity could be expected when evaporation was complete. The most satisfactory of the liquids were neutral oil, middle oil, and the proprietary spray. Of these the first began gradually to lose its toxicity after about two months, but the other two continued to give a complete kill, from a fortnight's exposure, for more than six months, when the experiment was terminated.

In later and slightly different experiments, the effect of diluting neutral and middle oil with diesoline, and of saturating them with naphthalene, was investigated. A dilution with 25 per cent. of diesoline greatly reduced the fumigative power of both materials but saturation of the mixture with naphthalene largely restored the original toxicity. In this experiment middle oil proved to be more toxic and more persistent than either neutral oil or the proprietary spray. A saturated solution of naphthalene in diesoline proved a poor fumigant.

Scourability tests have been carried out with neutral and middle oil by the Gordon Institute of Technology, Geelong, and have shown that neither leaves any undesirable residue or stain. Other scourability tests made with middle oil and the proprietary spray have given the same result.

In view of the fact that only materials that volatilize completely could be used in treatments of scoured wool, a series of experiments similar to those already described was carried out using as test materials solvent naphtha, ortho-dichlorbenzene, saturated solutions of naphthalene in these two substances (at 70° F.), and the saturated solutions diluted with an equal volume of lighting kerosene. Naphthalene was incorporated to improve persistence, and kerosene to reduce cost. Ortho-dichlorbenzene saturated with naphthalene was the most toxic and persistent of these materials; this solution diluted with kerosene was only slightly less efficient.

(iii) *Stack Spraying Tests.*—A nozzle has been designed that enables a satisfactory distribution of liquid sprays to be obtained within a wool stack when used in conjunction with a jetting plant, and a technique for spraying stacks from above has been developed. With the object of determining the reduction obtained in the moth population in a stack by the use of the proprietary spray applied in this way, two identical stacks were built in different stores out of bales of approximately the same type of wool and with the same degree of infestation. The one stack, together with the whole of the rest of the store, was sprayed, and the other left unsprayed in an unsprayed store. Before spraying, the population of both stacks was determined by trapping the adult moths on tanglefoot traps suspended at a number of different points in the interior of each stack, and after spraying the population was again determined, and its subsequent fluctuations followed for a period of 2½ months. The results showed that the immediate effect of the spraying had been to reduce the population to about 1 per cent. of that calculated from the catch in the untreated stack and the ratio of the populations in the treated and untreated stacks before the spraying. Subsequent trapping has shown no sign of an appreciable increase in the population of the sprayed stack, such as might have been expected if numerous larvae in the less accessible parts of the stack had escaped the effects of the spray and had been able to emerge as moths some weeks after the treatment.

4. Insect Control of Noxious Weeds.

(i) *St. John's Wort (Hypericum perforatum).*—Three insect enemies of St. John's wort have now been established in Australia. Prior to 1942 only two insect enemies, *Chrysolina hyperici* and *Agrilus hyperici*, were known to be established; the latter only in very small numbers. During the latter part of 1942, however, a third species, *Chrysolina gemellata*, was found to have become established at Baker's Gully, Bright, Vic., as a result of liberations made in that locality during 1939. *Chrysolina hyperici*, the first of the overseas insects to become established, has shown a considerable natural spread during the past twelve months in most areas where it has been established. *Agrilus hyperici* is also making very satisfactory progress and rapidly increasing its numbers at several of the sites where it has been liberated. The general progress is such as to give ground that these insects will later give a useful degree of control of the weed.

Chrysolina hyperici has now dispersed along the Oven's Valley and German Creek for a distance of eight miles from the original establishment site near Oake's Bridge, Bright. Since 1939, when this insect was first found to be established, thirteen liberations have been made, mostly in widely separated districts of Victoria. Strong colonies have been developed in the field in such widely separated areas of St. John's wort infestation as Myrtleford, Harrietville, Tawonga, and Dargo. In areas where *C. hyperici* has become established, the defoliation of the host becomes increasingly common, causing restricted foliage growth and seed production, and a gradually increasing mortality in the host plants. In the immediate vicinity of Bright, some small areas have been completely cleared of St. John's wort. In one paddock which had long carried a heavy stand of the wort, complete control was effected in a period of two years.

In New South Wales, eleven liberations have been made within approximately the same period. Colonies of *C. hyperici* are developing satisfactorily in the Orange, Sodwalls, Mudgee, and Rylstone districts, while other smaller colonies are established in the vicinity of Tumbarumba. Apart from the Tumbarumba liberations, all others in New South Wales have been made since the end of 1940, and in the period which has elapsed the majority of them have made considerable progress.

Chrysolina gemellata is now becoming well established at Bright, and during the past year 5,700 were liberated at the top of Nullo Mountain, near Rylstone, N.S.W., where there is a solid stand of St. John's wort amongst open forest country, extending over several thousand acres.

Agrilus hyperici, a root-boring Buprestid, was introduced from southern France and liberated in 1939 and 1940 in two districts, one in Victoria and the other in New South Wales. It has become established at each of the seven sites where liberations have been made. At several of these sites the population is increasing rapidly, and in the vicinity of one of them 50 per cent. of the plants are infested. Some plants have been killed, while the growth of others has been restricted. If the increase in numbers is maintained, a considerable effect on the weed should become apparent within the next few years at this particular liberation site. The Victorian liberations of *Agrilus hyperici* have all been made at Baker's Gully, Bright. In New South Wales three colonies have been established in the Mudgee district; two at "Yamba," Piambong, and one on the Catchment area. Here progress is very satisfactory, though not so rapid as at some of the liberation sites at Bright.

(ii) *Lantana (Lantana camara).*—There have been no recent developments in regard to *Teleonemia scrupulosa,* and the position is much the same as that recorded in the previous report. While the position in northern Queensland appears to be quite satisfactory and to be improving as time goes on, no further evidence is available to suggest that liberations in southern Queensland and northern New South Wales have been successful.

5. Sheep Blowfly.

Work on the sheep blowfly problem has been drastically curtailed during the year owing to the necessity of transferring staff to problems of medical

entomology. The most important advance made was the improvement of the contact toxicity of the B.T.B. blowfly dressing. This was achieved by replacing the original tar oil fraction with a mixture of different kinds of non-irritating contact agents. Laboratory experiments and limited field tests have shown the modified dressing to be very effective.

6. Medical Entomology.

The work of this Division on medical entomology has been expanded considerably. Most of the problems have been investigated in conjunction with Army entomologists or at their request. These have included the study of sprays for use against flies and mosquitoes, insect repellents, and oils for use against mosquito larvae. For security reasons these investigations cannot be discussed here.

7. Cattle Tick.

Work on the biology of the cattle tick has been continued. The study of the length of the life of non-parasitic stages at constant temperatures has been completed, and investigations are now being made of the effect of fluctuating temperatures and humidities, similar to those found in the field, on the length of life and viability of the same stages.

Laboratory and field investigations of dips have been made, including the questions of the composition of the dips, wetting properties, the retention of films of dip on the ticks, and the mechanism of the penetration of the integument. It was shown that larvae in the parasitic stage are much easier to kill with arsenic than in the non-parasitic stage. Following suggestions that the use of salt water improves the efficiency of dips, tests were made but no improvement was observed.

It has been claimed that an arsenic-resistant strain of tick has appeared in certain districts in Queensland. In association with the Queensland Department of Agriculture and Stock, investigations have been made to test these claims. It has been shown that dips as at present used fail to control ticks in some districts, but it is clear that, even if an arsenic-resistant strain of tick does occur, the failure of the dips is often due to other causes. There is some evidence that there is an arsenic-resistant strain of tick, but this is not at present conclusive.

8. Buffalo-Fly (*Lyperosia exigua*).

During the past year this pest spread to the east coast of Australia and has moved as far south as Townsville. It threatens to extend its range far down the east coast. An officer of the Division of Economic Entomology has been sent to the newly infested districts to make a preliminary study of the problem with the object of selecting the best centre for future work on the problem and of obtaining the information required in order to draw up an adequate programme of research.

9. Australian Plague Locust (*Chortoicetes terminifera*).

Work on the locust problem has again been mainly confined to field investigations in the Bogan-Macquarie (Warren-Dandaloo) outbreak area. Unfortunately, the impossibility of securing labour to carry out essential constructional work and fencing has made it necessary for the scientific staff to devote a considerable proportion of their time to work of this kind, with the result that it has been impossible to adhere to the programme of research mapped out for the season. This preparatory work is now almost completed.

(i) *The Locust Position During 1942-43.*—The season was noteworthy for a serious deterioration in the locust position in New South Wales. After ten months, during which not a single swarm had been reported anywhere in the State, a few swarms had appeared in the Warrumbungles outbreak during the 1941-42 season, but generally unfavourable conditions in this area had prevented any great increase or spread of the infestation. The spring and summer of 1942-43 were extremely favourable, however, and by November swarms were reported in as many as six different outbreak areas in the northern and central parts of the State. These swarms spread considerably in the usual directions, invading extensive areas of new country and laying there. In December a second generation hatched over the whole of the infested area, and when this generation became adult in January and February it migrated still further south and east. During January the number of swarms was increased by swarm formation in two additional outbreak areas, bringing the total of active areas to eight. The second generation laid very extensively, but dry conditions supervened, and these eggs had still not hatched with the arrival of winter temperatures in June. Whether they will be capable of hatching in the spring of 1943 cannot be predicted.

Although swarm-formation occurred in the Bogan-Macquarie outbreak area, it was not observed on any of the properties on which investigations are being carried out from the Trangie Field Station, so that the opportunity of studying the details of this process was missed. However, the Trangie district was invaded by swarms formed further to the north, and baiting had to be carried out on a few properties.

(ii) *Work on Pastures and Soils.*—Work was continued on the species composition of the herbaceous cover developing on the eight main soil types recognized in the Bogan-Macquarie outbreak area. Observations were made at type sites of each soil type at different times of year.

(iii) *Methods of Control in the Outbreak Centres.*—Parts of four outbreak centres in the immediate neighborhood of Trangie have been fenced to permit of the testing of treatments designed to render these areas incapable of producing swarms of *Chortoicetes*. Each fenced outbreak centre has been paired off with an unfenced control which will not receive treatment. Treatment consists of ploughing the bare ground of the oviposition site with a view to stimulating pasture growth, planting a barrier of trees between the oviposition site and the food-shelter nucleus (concentration zone), or a combination of both measures. Results so far obtained with ploughing alone have not been very encouraging. Although the pasture cover was improved, particularly in one of the treatments, considerable bare areas still remained, and after twelve months the ground was already becoming compacted once more, so that it was questionable whether the improvement would be permanent. After consultation with officers of the Commonwealth Forestry Bureau and the New South Wales Soil Conservation Service, the following species of trees and shrubs were selected as being the most suitable for the tree-barrier treatment: old man saltbush (*Atriplex nummularia*), *Myoporum montanum*, pepper-tree (*Schinus molle*), and river red gum (*Eucalyptus camaldulensis*). These species have been either cultured at the Trangie Field Station or obtained from elsewhere, and a first lot, comprising mainly peppers, was planted out in the autumn.

In connexion with the problem of producing a pasture cover on scalded areas suitable as oviposition sites, two such areas, in addition to those forming part of the outbreak centres already mentioned, have been fenced off with a view to comparative testing of various pasture species.

(iv) *Laboratory Work.*—The experimental work on the effect of constant temperatures and relative humidities on the rate of development and mortality of *Chortoicetes* was continued. The results obtained are of some interest in relation to field observations on the importance of "shelter" in locust habitats. The temperature at the surface of bare sunlit soil in the regions inhabited by *Chortoicetes* frequently exceeds 130° F. for several hours a day during the summer. Thus newly hatched hoppers on an egg-bed may be rapidly killed by heat unless plants casting a little shade are within their reach. The results obtained at 110°, combined with those reported previously at 90° and 100°, indicate that the optimum for rate of development and survival lies near 100°. A rough test using rather small numbers of hoppers indicated that 100° was more favourable than either 95° or 105°; at 105° none of the hoppers reached the adult stage. In the field 104° F. has been found to be the temperature selected for basking by adults and advanced nymphs, and the preferendum for young nymphs is probably below this, so that in this species the preferendum apparently coincides with the temperature that is most favourable biologically.

10. Red-Legged Earth Mite (*Halotydeus destructor*).

Owing to shortage of staff and the pressure of war-time work, it has unfortunately been found necessary to interrupt the investigation of this pest for the time being. The only work carried out during the past year has been further analysis of data obtained previously, and the preparation of accounts of the work for publication.

11. Oriental Peach Moth (*Cydia molesta*).

In the Goulburn Valley, infestation on all varieties of peaches was light during the 1942-43 season. In December, 1942, a survey similar to that made the previous year, was made by an officer of the Victorian Department of Agriculture to determine whether the parasite *Macrocentrus ancylivorus* had become established. No further parasites were introduced from the United States of America. As in the previous season, no evidence of the presence of introduced parasites was obtained, and it must be concluded that they have failed to establish themselves

12. Potato Moth (*Gnorimoschema* (*Phthorimaea*) *operculella*).

The potato moth caused severe crop losses on the mainland in the season 1942-43. These losses, under war-time conditions, are very important because of the greatly increased demand for potatoes and the shortage of manpower.

The results of studies on the effect of the acetylene treatment of potato tubers on potato moth, and the use of inert mineral dusts as a means of control for potato moth in tubers were published in the Council's *Journal* (Vol. 15, pp. 268-269 and pp. 257-261, 1942).

Experiments were carried out with a number of materials used as sprays for the control of potato both larvae in the haulms in the field. Of these, basic copper arsenate gave the most promising results. It appreciably reduced the destruction of growing shoots and prolonged the growing period of the plants. The experiments need to be repeated to obtain conclusive results. It has been found that the potato moth is very seldom attacked by parasites in Australia. Arrangements have consequently been made for the collection of promising parasites of this pest in California and for their introduction into Australia during the coming season.

13. Cabbage Butterfly (*Pieris rapae*).

During the past season this recently introduced pest has considerably extended its range in Australia. Further consignments of the parasites *Apanteles glomeratus* and *A. rubecula* have been received from England and have been bred under laboratory conditions. Further liberations of *A. glomeratus* have been made and evidence that it has become established in the field was obtained.

Field tests with several sprays and dusts for the control of this pest have also been made.

14. Underground Grass Grub (*Oncopera* spp.).

A further trial consignment of the parasite *Alomya debellator* was received, but unfortunately at a time when the host insects were in an unsuitable stage for attack. The chance of this parasite proving successful seems small.

15. Green Vegetable Bug (*Nezara viridula*).

A further attempt to introduce the parasite *Trichopoda pennipes* from Florida was made. Owing to certain features of its life cycle, this insect is particularly difficult to transport over long distances and, as a result, only a few weakened parasites survived the journey. Efforts are being made to improve the methods of sending. Some small-scale tests with dusts for the control of this pest were made.

16. Rutherglen Bug (*Nysius vinitor*).

A preparation consisting of creosote, naphthalene, and soft soap, referred to as "Creonaph," was found to be more effective against this pest than any other spray tried. Efforts are being made to improve the spray, for though it appears safe when used on many kinds of plants, it was observed to cause some injury to certain others.

17. Aphids.

A scarcity of nicotine sulphate, which is largely imported from overseas, has made the problem of aphid control very real. Therefore, a search was made for some insecticide available in Australia and effective enough to be used as a substitute. In field tests it was found that "Paranaph," as developed by H. A. Cousins in 1895 (*see* Council's *Journal*, Vol. 16, pp. 107-108, 1943), was very effective when used against cabbage aphid, *Brevicoryne brassicae* L., but was not so good as nicotine sulphate when used against green peach aphid, *Myzus persicae*, and potato aphid, *Macrosiphum gei*. When used against cabbage aphids, its great advantage over nicotine sulphate is its effectiveness at temperatures as low as 50° F. Its extreme wetting properties enable it to wet the insects on impact, and thoroughly wet the plants sprayed.

18. Citrus Red Scale (*Aonidiella aurantii*).

Three consignments of the Chinese race of the parasite *Comperiella bifasciata* were received from California during the past season. These parasites were bred in large numbers under laboratory conditions and later were distributed to entomologists in Queensland, New South Wales, Victoria, South Australia, and Western Australia. There are already indications that *C. bifasciata* has become established in the field in several States.

19. Brown Olive Scale (*Saissetia oleae*).

Two consignments of *Metaphycus helvolus*, a parasite that has proved particularly efficient in controlling the above scale in California, were introduced into Australia during the past season. It has been bred under laboratory conditions, but so far only small numbers have been liberated in New South Wales. This parasite attacks several other pest scale insects besides the brown olive scale.

20. Insect Vectors of Plant Virus Diseases.

(i) *Tobacco Yellow Dwarf.*—Since the completion of a study of the life-history, habits, distribution, and host preferences of the brown jassid, *Thamnotettix argentata* Evans, mentioned in the last report, further investigations on tobacco yellow dwarf have been suspended for the duration of the war.

(ii) *Potato Virus Diseases.*—(*a*) *Aphid Survey.*—The detailed survey, begun in 1941, on the abundance of the green peach aphid, *Myzus persicae* Sulz., and the potato aphid *Macrosiphum gei* Koch, vectors of leaf roll and mosaic viruses of potato, was continued at Black Mountain and Dickson, Canberra, A.C.T.

In Canberra, eggs of the green peach aphid were laid on peach trees in the autumn, and the aphid continued to breed throughout the winter on cabbage and swede plants in the experimental plots. The first flight occurred at Black Mountain on August 24, 1942, and the first mass flight was recorded in the mechanical nets on October 2. Apterous forms appeared on potatoes in the experimental plots on September 9, after which the population increased to a peak on October 22, a month earlier than the preceding season. After this, the population decreased and disappeared for three months from about the middle of December. In March, 1943, a small autumn generation appeared on potatoes and produced winged migratory individuals.

The potato aphid again bred on a number of host plants throughout the winter, chief of which was sow thistle, *Sonchus oleraceus,* and invasion of the potato plots in the spring began about the same time as the green peach aphid, rose to a peak of population early in November like the preceding year, and then disappeared from potatoes for the rest of the season. Breeding continued slowly on a number of host plants throughout the summer, and then increased to a peak of population in the late autumn when winged migratory individuals appeared.

The population of both species was very much lower on potatoes in 1942-43 than in the 1941-42 season.

21. Systematic and General Entomology.

Throughout the year, numbers of insects have, as in the past, been identified for institutions and individual workers throughout Australia and New Zealand. In addition a considerable amount of time has been devoted to assisting scientific workers with various taxonomic problems.

As a result of field trips during the past twelve months and by exchange with other entomologists and institutions, further additions of specimens have been made to the Divisional collection. These additions consisted mainly of insects of economic importance, either not previously represented or else represented by inadequate material.

Information concerning methods of controlling pests in stores of equipment has been made available in response to requests from the various fighting services. This work included advice on the control of cockroaches, clothes moths, and other insects responsible for damage. The Australian Army Medical Services have been assisted by the loan of Culicidae from the Divisional collection for use in the identification of mosquitoes as part of the general scheme of control. In addition, information about the occurrence and distribution of certain types of insects known or suspected as vectors of certain diseases, has been made available to assist the Australian and Allied forces.

IV. ANIMAL HEALTH AND NUTRITION INVESTIGATIONS.

1. General.

Previously the programme of work had been modified to meet war-time needs and the depletion of staff. During the year the work proceeded very much as during the preceding year. More attention was given to the immediate needs of the animal industry and to the application of existing knowledge for the prevention of wastage.

As in the past, the work has been carried out at the three main centres in Sydney, Melbourne, and Adelaide, as well as at the field stations at Cunnamulla (Q.), Badgery's Creek (N.S.W.), and at Werribee (V.), and in addition on several private properties. Co-operative work with the State Departments of Agriculture has continued. Inter-Divisional co-operation has been maintained through the Veterinary Entomological Committee, the Agrostological Committee, and the Drought Problem Committee. Some officers of the Division of Industrial Chemistry and of the Division of Food Preservation have been housed and given facilities at the Laboratory in Parkville, Melbourne.

2. Animal Health Research Laboratory, Melbourne.

(i) *Pleuro-Pneumonia of Cattle.*—The complement-fixation test elaborated by this Division has continued to give very satisfactory results in the control of outbreaks of the disease by State Departments of Agriculture and Stock, to whom antigen for the test is supplied. Antigen is also supplied at special request to the Stock Departments in Kenya and Tanganyika.

During the year, 454,650 doses of culture vaccine were forwarded to distributing centres, mainly in Queensland and Northern Territory. An experiment, designed to compare the degree of immunity six months after vaccination with freshly prepared vaccine and with vaccine kept at 4° C. for 56 days, showed no significant differences; in each case 20 head of cattle showed no signs of infection when autopsied five weeks after exposure to atomized culture, although one and two animals, respectively, had given transient positive complement fixation reactions, whereas 18 out of 19 controls became infected and showed lesions when autopsied.

Field reports have indicated that calves do not respond well to prophylactic vaccination. The susceptibility of very young calves to experimental vaccination was examined: 10 calves from 1 to 14 days old, vaccinated at the tip of the tail, neither showed local reaction nor developed complement-fixation reactions. One calf three days old developed swollen joints from which the causal organism was isolated.

Progress has been made in preparing and assembling the groups of vaccinated cattle for the experiment designed to determine the influence of a very low plane of nutrition upon the maintenance of immunity against pleuro-pneumonia. These groups will be tested for immunity after three years, together with others which will have been vaccinated for shorter intervals.

(ii) *Entero-Toxaemia of Sheep and Other Diseases Due to Clostridia.*—The results of work referred to in the last report have been published. This work having clarified the principles according to which strains of *Cl. welchii* type D should be selected for preparing anaculture vaccines, attention has been directed to defining the optimal conditions for toxoiding with formaldehyde. The optimal temperature, concentration, and time have been defined for

bacteria-free toxin so as to reduce to the minimum the antigenic loss during toxoiding. The next stage is to extend these studies to whole cultures.

A study of the haemolysins of the *Cl. welchii* group has led to a great extension of the knowledge of the delta haemolysin of type C, the causal organism of the sheep disease "struck," which has not yet appeared in Australia, and to the development of a haemolytic reaction on blood agar which is likely to be of great value as a presumptive test for the organism. This work will be the subject of a publication.

Observations on the nature of the normal anti-haemolysin mechanism of blood have yielded information which may be of some practical value.

(iii) *Caseous Lymphadenitis of Sheep.*—Study of the antigenic make-up has continued as opportunity allowed, and is likely to be considerably aided by the separation of several variants. The vaccination experiment referred to in the last report is continuing.

(iv) *Bovine Haematuria.*—All active work on this disease was brought to a close during the year. The cause of the disease has remained obscure. An adequate investigation calls for intensive chemical and biochemical investigation in the enzootic areas, and this cannot be undertaken under war-time conditions.

(v) *Myxomatosis.*—The field trial which had been planned for some time was started in October, 1942. Some early results obtained were very favourable, but in other areas and at other times of the year the results were quite unfavourable, no control of the rabbit population being obtained. It has been explained in previous reports that the disease, although very deadly and specific for the rabbit, does not spread very readily unless with the assistance of an insect vector. The presence of predatory animals, especially the fox, under field conditions favours the early removal of sick rabbits and with them all sources of infection. If there is rapid spread through the assistance of an insect vector the momentum gained may be sufficiently high to prevent the predatory animal from removing all sources of infection, and the disease may bring about an effective control of the rabbit population. The work has not been completed, but the indications are that the virus would be of use only under special and limited conditions.

(vi) *Mastitis in Dairy Cattle.*—During the year the last cow added to the experimental herd completed its fifth lactation period. This marked a point at which the first epidemiological study was brought to a close. The accumulated data have been subjected to statistical analysis, but this has not been concluded. During the year a start was made on a second epidemiological study by taking calves from a herd free from infection with the mastitis streptococcus and subjecting them to three different environments. Systematic bacteriological examinations will be made on the milk of these animals when they come into production. Also, during the year special attention was given to the development of recommendations calculated to limit the spread of mastitis in dairy herds and to alleviate the wastage caused. Recommendations were drawn up by the Investigation Committee, and they were based on the institution of efficient milking methods and the introduction of efficient disinfection of teats and teat-cups in the milking shed. Attention was also given to methods of treatment of cases of mastitis. The short supply of suitable drugs has limited the amount of work possible.

(vii) *Toxaemic Jaundice of Sheep.*—The co-operative investigation was continued. The experimental flock at Barooga was divided into two groups, one receiving free and unrestricted grazing, whereas the other was placed under restricted grazing. A few cases of toxaemic jaundice developed during the year, but in May and June the death rate increased dramatically soon after the ewes had lambed. Most of the sheep died rather suddenly, but some were seen to be obviously sick for two or three days or more. Jaundice was present in many of the animals sick or dead from the disease, but pathological examination revealed that the disease was distinct from toxaemic jaundice. There seems to be little doubt that in the past this disease has been regarded as a manifestation of toxaemic jaundice, and that it is responsible for very heavy mortality in sheep from time to time. The actual cause of the disease was not determined, although definite progress was made in the study. Further studies are expected to reveal the true nature of the disease and to point the way to its prevention.

(viii) *Peg-leg of Cattle.*—The experiment referred to in the last report has been unsatisfactory, mainly because the lick, compounded with the calculated requirements of iron, copper, nickel, cobalt, zinc, and manganese, has proved unpalatable. Even when the iron, zinc, and manganese were omitted, the lick was still not consumed. The trouble appears to be that intake of salt and bone-flour lick is not sufficient, and that the amounts of "trace elements" added are so concentrated as to make the lick unpalatable and thus defeat its purpose.

(ix) *Contagious Abortion of Cattle.*—During the year the Consultative Committee (Veterinary) representing States and Commonwealth gave consideration to the problem of the alleviation of wastage in dairy herds from contagious abortion. It was recommended that the attenuated strain of *Brucella abortus* known as Strain 19, which has been used for the vaccination of calves in U.S.A., might be used for vaccinating calves and non-pregnant adult cows in selected herds. The vaccination was to be under the control of the Chief Veterinary Officer in each State, and the vaccine, consisting of the live bacilli, was to be prepared in the Government Laboratories in each State. As the bacteria in the vaccine must be kept alive and the numbers must not be allowed to fall, the greatest care must be taken in its preparation and standardization.

In order to assist in this work, a special study of Strain 19 was undertaken. This included the study of growth requirements and the requirements for the longevity of suspensions to be used as a vaccine. Arrangements were made by which the laboratory could serve as a centre for the distribution of standard cultures to State laboratories and for the check on the standardization of the vaccine. Difficulties were encountered in the adoption of the standard methods evolved by the Bureau of Animal Industry, U.S.A. The standard nutrient medium is a potato agar, but as potatoes cannot be standardized a primary difficulty is met. Progress was made in overcoming this and other difficulties, and plans were made by some of the States to start the vaccination of selected herds.

(x) *Study of the Mechanics of Hand-feeding Sheep.*—An experiment was started to determine if sheep could be kept on a maintenance diet by giving them a week's supply of food at one time and thus save the labour of daily feeding. The feed selected was a mixture of equal parts of lucerne hay and wheat. One group was given the daily requirement each day and the other was given seven times this

amount once a week. The weekly fed group consumed all the food placed in front of it in two and a half to three days. The ration was increased during the cold weather. The experiment has proceeded for about seven months and at all stages the weekly fed group has utilized its food almost as efficiently as the daily fed group. The slight difference would appear to be of no practical importance, especially in view of the labour saved.

(xi) *Toxicity of Wheat for Stock.*—An investigation was started to determine the nature of the toxic phenomena that occur in sheep which have consumed large amounts of wheat. If the cause be known, prevention of the phenomena may be possible. In the preliminary experiments the erratic incidence of the untoward phenomena increased the difficulties of the investigation. Dramatic changes in the bacterial flora of the rumen and the rest of the alimentary canal were found. Attention was given mainly to the possible role of histamine arising from decarboxylation of histidine. The investigation is being continued.

(xii) *Periodicity of Oestrus of Sheep.*—Observations were continued on groups of sheep which received green feed for a period of three months at four different quarters of the year. They received dry feed during the remaining nine months. The effect of this regimen, which were more evident when the ewes were immature, were on the percentage incidence, but the period of maximal activity was not altered.

(xiii) *Miscellaneous. — Aesculin from Bursaria spinosa.*—A high yield (up to 3 per cent.) of aesculin was obtained from the native shrub *Bursaria spinosa,* and methods were devised for extracting it.

3. The McMaster Animal Health Laboratory.

(i) *Parasitological Investigations.*—(*a*) *Epidemiological Studies.* — Observations were started in Queensland at Goondiwindi, Karara, Yandilla, Macalister, and Jondaryn. Some broad relationships between changes in worm burden and weather conditions were found, but the observations must be extended before conclusions can be reached. Further observations were started in central Queensland at Clermont, Capella, Emerald, and Gindie, and in western central Queensland at Aramac, Barcaldine, Blackall, and Corfield. These are being carried out in co-operation with the Queensland Department of Agriculture and Stock.

(*b*) *Further Studies with Phenothiazine.*—For the control of *Oesophagostomum columbianum* (nodule worm) it is necessary to remove all the worms from the gut if possible. It was found that after a single dose of 40 g., which is twice the usual dose, all the worms were removed from 14 experimental sheep A single dose of 20 g. removed all the worms from 11 of 14 sheep, but a second dose of 20 g. removed all the worms remaining in the three sheep. As the double dose is likely to remove all the worms from all the sheep treated, it should prove successful in plans for rigid control of eradication of *Oe. columbianum.*

To determine the efficiency and safety of suspensions of phenothiazine which have been stored for any length of time, three preparations were tested after various periods of storage. The results showed that storage for eight months did not impair their anthelmintic properties, and substances toxic to the sheep were not evolved.

(*c*) *Anthelmintics Against Haemonchus contortus (Large Stomach Worm).*—Experiments were carried out on the efficiency of sodium arsenite, arsenic pentoxide, copper aceto-arsenite, and tablets containing copper sulphate and sodium arsenite. The tablets proved to be quite ineffective. Another experiment demonstrated that emulsification does not impair the anthelmintic efficiency of carbon tetrachloride. Oil of turpentine in a salt lick, as used by some graziers, was tried and found to be quite valueless.

(*d*) *Search for New Anthelmintics.* — A large number of organic and inorganic compounds were tested to determine their anthelmintic efficiency against the common internal parasites. Many were found to be without anthelmintic effect and others were found to have little value.

(*e*) *Parasitological Studies at Armidale.* — The epidemiological studies were continued and the results of the broader relationships observed were used to draw up an outline of an annual plan for the control of haemonchosis, trichostrongylosis, and oesophagostomiasis in northern N.S.W. The treatment of haemonchosis under "outbreak conditions" was investigated. It was found that under outbreak conditions phenothiazine is the only anthelmintic which is highly efficient. It was also found that the movement of sheep after treatment to a paddock which has been spelled for three weeks or more has definite value.

(ii) *External Parasites of Sheep.*—(*a*) *Control of the Skin Mite Psorergates ovis.*—Observations were made on the stability of polysulphide dips under use in the field. In one experiment 10,000 sheep were put through a dip made from a proprietary concentrate containing approximately 20 per cent. of polysulphide sulphur. The dip was adjusted to 1 per cent. polysulphide sulphur. Dipping was carried out over a period of seven days and the dip was replenished with 1 per cent. polysulphide in water. Additional concentrate to maintain reasonable strength was added on one occasion. Scrapings from the skin of the sheep were examined periodically after the dipping, and mites could no longer be found.

(*b*) *Study of Dips and Dipping.*—Included in the observations made were the estimation of suint in dipping baths and the estimation of arsenic absorbed during dipping operations.

(iii) *The Blow-Fly Strike Problem.*—Assistance was given in the campaign for the application of strike control methods in New South Wales. The experience led to improvement in the breech operation method. Further study of tail strike was made, as well as of tailing methods to give the optimal tail length for protection against strike.

(iv) *Infectious Diseases of Sheep.—Pizzle Rot.*—Field experiments showed that a period of fasting or of low food intake for about three weeks caused the lesions to heal in the majority of affected wethers.

(v) *Biochemistry.*—(*a*) *Pregnancy Toxaemia in Sheep.*—Study was made of the effect of a sudden and severe check in food supply in a flock of 500 Merino ewes due to lamb and in good condition. The check precipitated about 90 cases of pregnancy toxaemia in the flock. All the ewes that became affected, with only two or three exceptions, were carrying either twins or triplets. Data from pathological and biochemical examinations have not been completely studied.

(*b*) *Oxalates in Plant Material.* — Chemical analyses were made of two species of Portulaca and one of Oxalis. The values for total oxalate content ranged from 8.5 to 15.5 per cent. Consumption of these plants was possibly associated with an outbreak of clinical hypocalcaemia in ewes.

(*c*) *Studies on Mineral Metabolism of Sheep.*—Studies were continued on the influence of supplementing with calcium, sheep rations which contain a

high proportion of cereal grains and their by-products. The standard ration was wheaten chaff 44 parts, oats 25, bran 25, linseed meal 5, and sodium chloride 1 part. Lambs weaned on to this ration suffered 100 per cent. mortality. A large proportion of deaths occurred within from 3 to 6 months. Weaners and adult sheep became severely hypocalcaemic. Serum magnesium and inorganic phosphate were considerably elevated. Dental development was grossly affected in every instance. Appetite was seriously affected within 2 or 3 months. When the ration was supplemented by the addition of 1 per cent. finely ground limestone all these abnormalities were prevented. However, the supplement had little or no curative effect when given after the abnormalities had developed. The limestone must be finely ground to be efficiently utilized by the sheep. Experiments failed to show that slaked lime is a satisfactory substitute for finely ground limestone. Experiments were also started with mixtures containing equal parts of wheaten chaff and grain, either maize, oats, or wheat.

(*d*) *Urinary Calculi in Sheep.* — Experimental animals on the cereal diets have shown a tendency to form calculi in the urinary tract. The underlying cause of these urinary calculi has been under investigation which is extended to the study of calculus formation under natural conditions. Evidence so far accumulated suggests that a high magnesium content of the urine is a contributing factor to calculus formation.

(vi) *Chemical and Physical Studies on Wool.*— Chemical analyses were made on fleece samples as part of an investigation into the factors associated with susceptibility to fly-strike. The results show that there appears to be a relative increase in epithelial debris to clean dry wool in samples from the crutch of susceptible sheep. The ratio of nitrogen to clean dry wool was, on the average, 32 in fleece from suspectible as against 18 for the more resistant sheep.

On account of the exigencies of war, study on the physical properties of wool has been interrupted.

(vii) *Wool Biology.*—(*a*) *Biological Analysis of the Fleece.* — Further advance was made towards establishing a method of analysis by which the main sources of biological variation within and between fleeces can be studied under well-controlled and uniform conditions. In one series of observations Merino ewes with obvious individual differences both in type of fleece and in conformation were studied for two experimental periods of about 100 days each. The observations included the rate of production of dry wool per unit area of skin, rate of growth in fibre and staple length, rate of crimp formation, rate of production of wax and suint, variation in fibre thickness, fibre and follicle population density, variation in skin wrinkles, variation in body weight, and daily food intake. Observations on the skin and fleece characters were made on eight different body regions of each animal.

(*b*) *Progeny Testing in Sheep.*—Further progress was made towards establishing methods of conducting progeny tests with Merino rams under station conditions. The observations are concerned with the more limited objective of establishing methods of husbandry, measurement grading, and statistical analysis which are necessary before the system for the selection of sires can be put into practice. During the year 230 progeny of 22 sires were evaluated on two occasions at the ages of 7 and 18 months, respectively. The characters evaluated were (1) body weight, (2) raw fleece weight, (3) yield per cent., (4) clean-scoured fleece weight, (5) staple length, and (6) approximate fibre uniformity grade. In addition the progeny were graded for the degree of skin fold development.

(*c*) *Study of Primary and Secondary Follicles and Their Fibre Types.*—Using skin sections a study was started on the separate populations of primary and secondary follicles and of their characteristic response to environmental change.

(*d*) *Fleece-Density.*—Material was collected from many sources for the study of the range of variation in the follicle and fibre population density. Most of the important Merino strains in Australia are represented in this collection. Values ranging from 14,000 to over 90,000 fibres per square inch have been found and indicate the remarkable possibilities for variation in the fibre population density in the Australian Merino. The constitution of this population also varies. The ratio of primary follicles to the total follicle population was found to range from 6.0 to 37.0 or, expressed as a percentage of primary follicles, from 2.7 to 16.7. The range of density for primary follicles alone was from 1,400 to 4,500 per square inch. Therefore, among the domestic breeds of sheep the Merino has an unparalleled variation in the hair follicle population density.

(*e*) *"Banded" Wool in the Merino.*—The nature of "banding" in pigmented wools from Queensland was placed under study.

4. The F. D. McMaster Field Station.

(i) *General.* — (*a*) *Seasonal and Pastoral Conditions.*—From July 1, 1942, to May 17, 1943, 25.6 inches of rain fell. Rain in November and December was favourable to intestinal parasitism and there was some increase in blow-fly strike. Last season's oat crops yielded approximately 55 tons of hay. A 15-acre crop of sorghum was sold standing in the paddock. This season's oat crop, approximately 50 acres, is well advanced and should provide a considerable quantity of winter grazing. Eighteen acres of Berseem clover was also sown.

(*b*) *Livestock.*—The lamb shearing and crutching tallies provided a count of all sheep on the property. The figures were 109 rams, 62 wethers, 618 ewes, and 184 lambs; total 973. Sale was arranged for approximately 200 surplus sheep. Sixty-two Boonoke-bred ewes and three rams were purchased from Dookie Agricultural College, Victoria, during the year. The remaining Zebu heifer is well and has been running with a Jersey bull for some time. There are seven draught horses and one light horse on the Field Station.

(*c*) *Afforestation.*—No new work was undertaken, but the eucalypts already planted have made satisfactory progress.

(*d*) *Improvements.* — About 50 chains of subdivisional wire fencing were erected. Painting and building programmes were suspended.

(*e*) *Staff.* — Although progress cannot be outstanding under the conditions of a depleted staff, no problems have been discarded but others have been undertaken. The overriding plan is to accumulate experimental animals of known pedigree and from planned matings. Data from these will be available for adequate examination when the research staff is augmented.

(ii) *Zebu Hybridization.*—A comprehensive report was prepared for publication. It discusses the problem as an ecological experiment and reviews the whole position. Analyses of data disclose minimal possible advantages of the method to be an annual increase of about 9,000 tons of beef, worth approximately £245,000. In addition, and resulting from cross-bred cattle being ready for market at least one

year earlier than British-bred cattle of similar weight, there would be an increment of 392,331 bullock-years; equivalent approximately to an additional 7,000 square miles of country capable of carrying 20 head of cattle to the mile. The only deterrent is the temperament of the cross-breds, but, as work during the nine-year period under review has shown, this difficulty is readily surmountable.

(iii) *Fertility of Sheep.*—The results of upwards of 200,000 observations during a period of five years on the occurrence of oestrus have been examined and prepared for publication. The observations disclose that all ewes, including Merinos, have annual seasons of high or low sexual activity. In the late spring and early summer months sexual activity is lowest, commonly resulting in a non-breeding season. However, although this is so for the mass behaviour of diversified breeds and strains of sheep in widely different environments, individual behaviour is characteristic of some ewes. These differences are attributed to the individual heredity of the ewes and probably provide material from which early, mid-season, or late varieties could be selected. Supplementary investigations were undertaken at "Gilruth Plains," south-west Queensland, and at Werribee, Victoria.

(iv) *Inheritance of Skin Wrinkles in Sheep.*—Numbers are still being increased and the investigation is proceeding according to plan.

(v) *Inheritance of Pigmented Wool.* — A final mating has been made and reported for this project. It supports the earlier hypothesis that pigmentation, as defined earlier, is a recessive condition. Apparently it depends upon one of a pair of genes. The dominant allel probably inhibits pigmentation. The other two aspects of the problem, namely, pattern and intensity, probably are polygenic. Work upon them has been discontinued because an adequate number of experimental sheep would overstock the property.

(vi) *Inheritance of Horns in Sheep.*—Results to date are confusing principally because we have not yet been able to secure or breed a "depression" ram. However, work is continuing in the hope that when we do get a ram of that nature, which should be homozygous for polledness, our present data can be straightened out.

(vii) *An Inbred Flock of Australian Merinos.*—Sixty-two ewes and three rams of the same strain have been added to the group. Matings to date have not been consanguineous but appropriate lines are being built up. These sheep are being used extensively for wool studies.

(viii) *Faults of Merinos.*—A new departure has been to co-opt leading stud-masters and to invite them to specify outstanding faults of Merino sheep. These have been confined largely to those other than wool faults or to them only in a general manner, *e.g.* to hair. The faults have been classified according to their importance. Sheep have been secured and matings are being arranged to determine the part heredity plays in the incidence of the faults. Already three such investigations are under way; on "parrot mouth," "hair," and "grip." "Development" is being investigated as "wrinkling." Rams with all these faults are being mated with appropriate ewes.

(ix) *Wool Fibre Measurements.* — Wool fibre diameters have been associated with spinning counts, and the uniformity within a series of such measurements has been the subject of wide interest. Little has been done to determine whether the particular distribution curves are characteristic of individuals, whether the shapes have hereditary associations, or at what age the curve becomes stabilized, if this takes place. These possibilities have been placed under investigation.

5. The Animal Nutrition Laboratory, Adelaide.

(i) *Energy Metabolism.*—The investigations concerning the efficiency with which the sheep utilizes the available energy in its fodder that were mentioned in the previous report have been completed. This information provides a chapter in a comprehensive study of the energetics of ruminant nutrition, which is now in the course of preparation for publication as a scientific monograph. The nutritional energetics data provide the fundamental knowledge that is essential for the understanding of the nutrition of the sheep.

(ii) *Drought Feeding.* — (*a*) *Energetics.* — The major part of this broad project is intimately associated with the study of energy metabolism mentioned above. Activity under this section has been for most part devoted to evaluating the capacity of various classes of feasible fodders to provide energy to the sheep; that in the former section has been concerned mainly with the utilization of energy by this animal, and has led to the discovery that a large proportion of the energy which is assimilated by the sheep from some fodders cannot be utilized by the normal metabolic processes.

The intensive study of the capacity of pure cellulose to supply useful energy is nearing completion. The generally accepted assumption that digested starch and digested cellulose provide equivalent amounts of energy for ruminants, which was founded on Kellner's classical determinations and which is the basis of current feeding standards, will need to be abandoned in the light of the unequivocal findings of these investigations. The new standards which have been drawn up and which are being subjected to exhaustive trial, will provide a precise, scientifically secure, and readily understandable basis not only for the procedure of hand-feeding, for which the investigations were originally designed, but also for all fundamental nutritional studies of the ruminant.

(*b*) *Vitamin A.*—The importance which vitamin A is likely to assume in dry grazing and drought feeding has been mentioned in previous reports. In order to provide a sound basis for the study of the vitamin A status of sheep grazing under various conditions in Australia, the correlation of the vitamin A and of β-carotene concentration in the blood with the extent of storage of the vitamin in the liver was investigated in experimental sheep confined in pens and fed on a diet practically devoid of vitamin A and of its precursor carotenoids. The results show conclusively that the vitamin A concentration of the blood remains constant until the liver stores are depleted, at which stage it falls precipitately and the deficiency symptoms of nyctalopia (night blindness) appear. Terminal symptoms of paralysis due to demyelination in the spinal chord supervened after 12 months on the deficient rations. The investigations have provided a sound and direct basis for surveying the vitamin A status of grazing flocks.

Two preliminary surveys have been carried out, and the results indicate that vitamin A deficiency is not likely to occur in flocks until they have been subject continuously to dry grazing conditions for approximately one year. The studies are being continued.

(*c*) *Inorganic Nitrogen in Drought Feeding.*—The symbiotic flora in the rumen of sheep are known to produce protein from simple nitrogenous substances. The factors which control this process are being investigated in order to determine the feasibility of

employing synthetic nitrogenous materials such as urea instead of more costly protein for supplementary and drought feeding. The results bear directly upon what is undoubtedly the most important economic problem associated with the nutrition of sheep.

(iii) *Influence of the State of Nutrition on Wool Production.*—The first series of experiments designed to determine the influence which the nutritional level exerts on the growth, the conformation, and the wool-growing propensity of Merino sheep has now been completed at the end of three years' intensive observations. The results clearly show the nature and the extent of the effects that nutrition exerts on the sheep themselves and have provided quantitative answers to many outstanding problems of sheep husbandry. The observations are being prepared for publication as a scientific monograph. The energetic and wool-growing efficiency of sheep that have been subject to different dietary regimes during their growing periods is now being estimated, and plans are being made to apply the knowledge to the selection of the most efficient types of sheep for each of the large variety of nutritional environments afforded by grazing conditions in Australia. The investigations concerning the influence of nutrition on wool production of Merino sheep have been considerably extended both by laboratory experiments and by observations of experimental flocks in the field.

(iv) *Plant Proteins.*—Work on the plant proteins has been continued during the year. Part of the period has been devoted to problems concerning the production of vitamin C in germinating seedlings and the development of methods suitable for the estimation of vitamin C in the presence of other reducing substances with which it sometimes occurs in natural foodstuffs. These latter investigations have now been completed, and a more comprehensive study of the amino acid constitution of the protoplasmic proteins separated from the leaves of *Phalaris*, lucerne, burr medic, &c., has been undertaken. Detailed study of the proteins from the seeds of *Lupinus* spp. and of legume seeds generally, which have become very important sources of protein for the nutrition of humans and of farm stock, is being carried out.

(v) *Physiological Studies.*—(*a*) *The Process of Deglutition in Sheep.*—These studies on the physiology of the complex stomachs of the ruminant have been completed and the results submitted for publication.

(*b*) Physiological studies concerning the passage of copper through the intestinal tract have been continued. The effect of various factors on the assimilation and storage of copper by Merino and other breeds of sheep is also being studied by balance technique.

(*c*) *Oxidizing Enzymes and Metabolism.*—A study of the enzyme system responsible for the intermediary metabolic processes in the sheep has been undertaken in connexion with the general problem of copper and cobalt deficiency.

(vi) *Minor Element Deficiencies.*—(*a*) *Copper Status of Sheep on Copper-Dressed Pastures at Robe.*—The investigations at this site, which for most part imply long-term experiments, have been continued and extended. The results from the trial to determine the ability of copper-dressed improved pastures to fulfil the copper requirements of sheep grazed in the deficient areas indicate that, although a marked beneficial response is invariable, additional copper supplements are essential to produce optimal health and wool production. Plans have been made for similar experimental observations to be conducted on other types of copper-deficient terrain.

(*b*) *Frequency of Administration of Copper Supplements.*—Although copper under some conditions is stored by the sheep in very considerable quantities, it is apparent from experimental observation of the performance of Merino sheep on copper deficient country at Robe that large doses administered once in five weeks are not as effective as correspondingly small doses administered three times weekly. The difference manifests itself most clearly in the nature of the wool.

(*c*) *The Reaction of Sheep to Administration of Excess Copper.*—The experiment designed to study difference in behaviour of Merino and Border Leicester sheep when treated with varying doses of copper while depastured on the deficient terrain at Robe has been continued. Very little obvious difference has been observed in the well-being of the two breeds at any one intake level up to 50 mg. copper per day. Five of the six Border Leicester animals receiving 100 mg. copper per day, however, have died showing haemolytic jaundice and other typical signs of copper poisoning. Only one of the corresponding Merino group has died, but two others have sickened, and the study has indicated that the Merino under these conditions is less susceptible to excess copper intake.

(*d*) *Copper Deficiency and Steely Wool in South Australia.*—Experimental trials were established at seven sites distributed throughout the slightly copper-deficient areas which constitute about three-fifths of that part of South Australia in which the annual rainfall exceeds 8 inches. The responses of the sheep to copper treatment were measured by the usual quantitative criteria in addition to the estimation of economic return which has been rendered possible by the current methods of wool appraisal. The differences in average monetary value between the clips from copper-treated animals and from their unsupplemented controls ranged from 3s. per head at Keith to nil at Sheringa, where effects of the deficiency are only noticeable in certain seasons. Arrangements have been made to test the efficiency of copper-dressed pastures on the two widely different soil types represented by the field sites at Borrika and Keith.

(*e*) *Frequency of Administration of Cobalt Supplements at Robe.*—It is apparent that cobalt is not stored to any great extent by the sheep. The experiments initiated in 1941 to determine the frequency with which cobalt supplements need be supplied to animals grazing on deficient pastures, are still in progress. The degree of well-being of the groups receiving cobalt at intervals ranging from three times weekly to once in five weeks correlates with frequency of the dosage and has retained its same relative position throughout the year. All individuals have now been mated so that the extra strain of pregnancy and lactation may be determined.

(*f*) *Minor Element Deficiency and Weaner Trouble.*—No response to cobalt supplements has been observed at Glenroy. An experimental trial to determine the cause of losses in young sheep was started at Pillana. It is already obvious that parasitism is a primary limiting factor in this area. The trials are being extended in collaboration with the McMaster Laboratory.

(vii) *Agrostological Investigations.*—The investigations during the past year have been devoted mainly to observations concerned with the persistence of the effect of copper and zinc manurial dressings on various fodder plants at Robe, where the deficient soil type is characteristic of the highly calcareous soils of the littoral of Southern Australia. It is evident that the beneficial effects tend to increase rather than decrease. Better dissemination of the dressings throughout the soil undoubtedly

plays a major part in this effect. It is now possible to establish lucerne and splendid permanent pastures on this type of deficient country. The intensive study of the factors involved has been taken up again and arrangements have been made for an extension of the work to other areas where the productivity of different soil types is limited by similar minor element deficiencies.

6. National Field Station, "Gilruth Plains," Queensland.

Seasonal conditions were more favourable to the investigational work being carried out than they were in the previous year. They were fairly dry in the second half of 1942 until the end of November. Heavy rains fell in December, but the early part of 1943 was consistently dry. The total rainfall for the year ending 30th June was 15.96 inches, of which 8.13 inches fell in December, 1942. The stock maintained their condition well throughout the year and from 2,907 adult ewes 81 per cent. of lambs were marked.

The following is a brief summary of experimental observations:—

(i) *Observations on the Control of Crutch Strike.*—The figures on the percentage incidence of crutch and tail strike during the previous twelve months were collected and analysed. The seasonal conditions had been dry and therefore the number of strikes experienced was relatively small. The results showed the value of the Mules operation and of the 4-in. tail. No strikes occurred in sheep treated by the Mules operation and having the 4-in. tail, but in the untreated control sheep and in those with medium or short tails, strike increased until it reached 25 per cent. in the controls with short tails.

During 1942-43 good rains were received in December and an increase in fly-strike was expected. In order to determine the relative resistance of crutched normal sheep as against uncrutched sheep on which the Mules operation had been performed, the control groups only were crutched. The results showed that the Mules operation and the longer tail do not remove the necessity for crutching at least once, usually at mid-season. As the "fly season" is short at Cunnamulla it has not been possible to compare the length of time sheep that have been operated upon remain protected after crutching compared with controls, but there is no doubt that the protection afforded by the operation does not remove the necessity for crutching.

Further information was received of the results obtained in the trial of the Mules operation at Rockwood Station, Tangorin. The strike incidence from the inception of the trial until shearing in August, 1942, was low, but the results were significant and showed 11 per cent. of strike in the control, medium-tail group, as against no strike in the "Mules" longer-tail group. These results again demonstrate the value of a combination of the Mules operation with the longer tail.

Further investigations were started on the most suitable length of tail and the best method to arrive at a standard practice so as to allow for the spread in age of lambs at marking-time. Similar trials are being carried out under several climatic conditions in Queensland and New South Wales.

(ii) *"Wasty Tip" Experiments.*—An experiment was carried out during the year in co-operation with the Shell Company to determine whether the application of a greasy spray to the wool is efficacious in preventing wastage of the tip due to sun and weather damage. No benefits could be demonstrated under the conditions prevailing, which did not favour damage to the tip of the fleece.

(iii) Experimental observations were continued on (*a*) animal husbandry methods in progeny testing of Merino rams, (*b*) the periodicity of oestrus under two methods of joining the rams, *viz.* continuous association on the one hand and association for one month out of twelve, on the other hand, and on (*c*) classing to determine at what age reliable results can be expected.

The observations have not been taken sufficiently far to permit discussion of results at this stage.

V. SOILS INVESTIGATIONS.

1. General.

The work of the Division of Soils has varied through the past year, initially with the emphasis on soil mechanics and latterly with renewed attention to the problems of primary industry with special reference to the coming needs of rural reconstruction. A considerable proportion of the total effort was concentrated on defence projects for the first half year. Field surveys and laboratory research have been restricted through lack of staff depleted by enlistment and secondment to other services; at the present time the shortage of experienced staff is becoming increasingly acute with the demands for service being made on the Division.

Work in the field has continued on a small scale compared with normal years. More use is made of the reconnaissance survey, although it is necessary to have detailed information wherever intensive land use is concerned. The policy of linking potential land use investigations with the soil survey is regarded as a logical development of field work. It is hoped that co-operative studies with workers in agriculture, forestry, irrigation, and economics, will soon come as a standard procedure for the most effective application of the basic soil survey.

In the laboratory, research has continued steadily in bacteriology and spectrography and on a small scale in soil chemistry. The main change has been the initiation of a strong programme of investigation in soil mechanics, principally concerning soil-cement, and with this it is proposed to continue as a major project.

The Division of Soils has its headquarters at the Waite Agricultural Research Institute, University of Adelaide, and its staff has been associated freely with University colleagues engaged on allied agricultural research. Ready co-operation has continued with the Departments of Lands, Agriculture, and Irrigation of the various States in which the Division has been active.

2. Soil Surveys.

(i) *South Australia.*

(*a*) *Loxton.*—At the request of the State Government, an area of 11,400 acres close to the town of Loxton on the River Murray was examined as a potential irrigation settlement. The Department of Lands carried out a contour survey at five-foot intervals, and the soil survey was subsequently made. The aim was to determine the nature of the soils for irrigation development and their probable suitability for various horticultural crops. From extensive experience on similar country it was possible to classify the soils in conformity with other established settlements. A report and soil map has been submitted dealing with the types of soils and their grouping according to suitability for citrus, canning fruit, vines, and vegetables. If the engineering evidence indicates that the area can be economically

supplied with water, some additional detail on soils and contours will be necessary for the proper planning of the area and the designing of the farms.

(*b*) *Mount Victor Area.*—An area on Mount Victor Station in the north-east of South Australia was mapped at the request of the Division of Animal Health and Nutrition. The area was the site selected for experiment in myxomatosis of rabbits for general control under field conditions.

(*c*) *Henley.*—At the request of the Department of Agriculture a small area of 300 acres near Henley was closely examined for its suitability as a vegetable-growing unit as part of the Commonwealth drive for mechanized production. The examination indicated the unsuitability of about half the area and the scheme was abandoned.

(ii) *New South Wales.*

(*a*) *Deniboota Irrigation District.*—The survey of Deniboota, proposed for development under conditions of limited irrigation, was mentioned in the previous report. The survey has since been reported on, with maps showing the distribution of the four major soil groups and land classification according to the expected relation to irrigation developments.

It is of interest to note that development of poor, heavy soils to rice growing is being vigorously pursued by the Irrigation Commission of New South Wales after several successful pilot trials. In the event of the crop being commercially sound, the outlook on the use of very large areas of poor and at present unsuitable soils may have to be drastically altered. The existing survey data on the distribution of such soils in south-western Riverina will be of great use in following up a policy of increasing rice acreage.

(*b*) *Berriquin Irrigation District.*—The survey of this district, the largest unit in the irrigated zone of south-western New South Wales, was recently begun. The Berriquin Irrigation District covers 940 square miles and extends from near Deniliquin to east of Berrigan. Owing to lack of soil surveyors, and in the absence of aerial photographic surveys, the survey is restricted to a broad scale with a view of obtaining a general picture of the soil types and their distribution, and limited data on their relation to irrigation development. Subsequently a detailed survey with the use of aerial photographs will be necessary for the proper mapping and evaluation of the area. Progress is reported.

(iii) *Aerodrome Surveys.*—A large number of soil surveys of prospective sites for aerodromes have been made; relevant soil samples have been examined in the laboratory.

(iv) *Divisional Reports.*—During 1942-3, 42 divisional reports were prepared for various Defence and State services, dealing with soil surveys, soil stabilization, and soil mechanics, and many of them included analytical data from the Division's laboratories.

3. Soil Chemistry.

Spectrochemical analysis of ironstone gravels was continued from the previous year with the development and testing of a promising method of quantitative analysis. Samples of soil and, to a lesser degree, samples of biological material differ considerably from samples of metals and alloys which are usually analysed by spectrochemical methods. A great deal of information has been obtained from the work on ironstone gravels, as they contain a large number of elements at low concentrations. They have proved very satisfactory as standard samples for the development of methods for quantitative spectrochemical analyses of soils. The chemical nature of these gravels is of scientific interest in the field of pedology and of practical importance in the field of agronomy.

In association with the Division of Industrial Chemistry, detailed analyses of a semi-quantitative nature were made of samples obtained from pyrite. The original ores and the concentrates and "tails" after the ore had been subjected to a flotation process were examined for the distribution of elements present at low concentrations in these fractions.

Also in association with this Division, an investigation was made of the practicability of the spectrochemical method for analysis of samples of purified bauxite. The analysis of bauxite by this method presents difficulties, and a number of elements of interest are present at very low concentrations in the original sample. It was found that useful information could be obtained without using any preliminary treatment of the sample.

Spectrochemical analyses were made of samples of plant material in connexion with the uptake of molybdenum under controlled conditions in glasshouse pot cultures. A number of ores and similar materials which had a possible value as trace element fertilizers were examined, as well as samples of recognized fertilizers.

On behalf of the National Standards Laboratory, complete qualitative analyses were made of a number of coloured glasses as part of an investigation of their suitability for welding goggles.

Qualitative tests were carried out on the effect of contact of soils treated with calcium chloride on various metals and alloys used in aeroplane construction.

Studies have been continued on the problem of anion exchange in soils. The phenomenon has been shown to have a probable bearing on the availability of anions of importance in plant nutrition, such as phosphate and molybdate and probably manganate and borate. Good methods for assessing quantitatively this particular behaviour of soils are still to be desired. In this connexion the response to liming of the Cressy shaley clay-loam, a Tasmanian soil which has for many years proved difficult of management, has been shown to be associated with an increased availability of molybdenum and probably of phosphate. The uptake of molybdenum by subterranean clover grown in this soil was estimated by spectrochemical methods and was observed to be materially enhanced by making the soil more alkaline.

4. Soil Physics and Soil Mechanics.

(i) *Soil-Cement.*—During the year a considerable amount of work was done in connexion with the use of soil-cement in paving surfaces. The investigation arose from the decision of defence services to use soil-cement as a constructional material and the desire of the Australian Cement Manufacturers' Association that research in it should be carried out.

The Division undertook preliminary study of the first major soil-cement project in Australia. Assistance was given in site selection, soil survey of area, and in testing to determine water, cement, and compaction requirements. Testing was also undertaken for the Highways Department, South Australia, to assist in the maintenance of required standards in water content and compaction during construction of a limestone rubble-cement paving in South Australia.

Three pavements, in the construction of which the Division assisted, have been further examined by measurement of cracking, and tests for compressive strength and durability of cores cut from them.

A programme of research was drawn up as a result of experience in construction work and a number of projects begun. The chief of these concerned the loss of density which had been found to result from the inevitable delays occuring between the wetting and rolling of the soil-cement mixture. It has been shown that such losses in density occur generally in soil-cement made from all but the sandiest soils. The importance of rapidity in processing has been further demonstrated by detection of considerable losses in compressive strength where there is a delay of one hour or more between wetting and compacting. The loss in strength is almost entirely due to the corresponding loss in density, and despite a delay of some hours it may be largely overcome if the material is compacted to specified density by the expenditure of additional energy.

It is proposed to continue with the research on soil-cement and engineering properties of soils. Five soils of diverse origin, texture and character have been studied comparatively in the above investigations. A mass of evidence is being accumulated on the relationship between soil types and their use in soil-cement construction, and correlation is being sought with American classifications and standards.

(ii) *Soil Stabilization.* — Investigations on the stabilization of soils with calcium chloride were carried out in the laboratory and in field plots. It was shown that dressings of up to 6 lb. flake calcium chloride per square yard were insufficient for stabilizing soils in inland southern Australia under concentrated traffic.

5. Bacteriology.

Symbiotic nitrogen fixation has been the principal subject under investigation, as it is a major factor in the establishment of populations of rhizobia of high "effectiveness" in the pastoral areas of South Australia. Existing pure cultures of *Rhizobium* have been maintained in the laboratory and tests made periodically for nitrogen-fixing capacity.

The Division has become the main collecting centre for type cultures in Australia, and a total of 60 strains covering cross inoculation groups of all legumes are maintained for reference or distribution.

An experiment has been conducted in the glasshouse to determine any possible benefit to a grass growing in association with a legume when the latter is clipped periodically to within an inch of the ground during the active growing period. So far no such benefit has been observed. A loss of nodules ensues with a possible release of nitrogen into the soil on their decomposition.

In collaboration with the Mineral Deficiencies group at the Waite Institute, work is nearing completion on an investigation of the effect of the trace element molybdenum on the nitrogen nutrition of grasses and legumes, particularly as it affects infection with *Rhizobium*.

Further strains of *Rhizobium* for more tropical legumes have been isolated. The method previously devised of growing tropical legumes in a heated cabinet to lengthen their growing season in Adelaide has been employed for continued studies of cross inoculation.

During the 1942 season, 840 cultures for inoculation of legume seed before sowing have been supplied to 126 individual farmers for sowing approximately 7,100 acres. This represents a considerable reduction on the previous season's figures, conforming to decreased supplies of superphosphate.

VI. IRRIGATION SETTLEMENT INVESTIGATIONS.

A.—COMMONWEALTH RESEARCH STATION (MURRAY IRRIGATION AREAS), MERBEIN, VICTORIA.

1. General.

The Commonwealth Research Station, Merbein, was established primarily for investigation of problems associated with the production and processing of dried fruit, including irrigation of the land and maintenance of soil fertility. At the outbreak of war, many of the major projects had reached the stage where the results of the investigations were incorporated in rural practices. Over the past two years, owing partly to diminished staff and partly to Commonwealth requirements for special products, some of the investigational work has been suspended and replaced by investigations dealing with special war-time requirements of the nation. The experience of the Station in primary production under irrigation conditions, and in the drying of foodstuffs, is being fully utilized by Commonwealth Departments dealing with the processing and storage of dried fruits and vegetables and in the production of special crops not previously grown in commercial quantities in Australia.

Fruit drying investigations have now been extended to practically all dried fruits required by the supply authorities and include attention to the end-point of processing, to preservatives, and to the general specifications necessary for high quality products. In connexion with the cultivation of plants for which the Commonwealth undertakes the financial responsibility of production, the Station has assisted in the development of approximately 500 acres of land, brought under irrigation since the advent of the war. The plants grown include vegetables at military establishments, grass covers for aerodromes, and drug plants.

The curtailment of the supply of certain requisites for dried fruit production and the provision of substitutes for substances not now obtainable, have required alterations in production and processing methods. The staff of the Station assists in an investigational and consultative capacity in these readjustments.

Certain long-dated investigations have been continued. These include the cumulative effect of fertilizers and of pruning on the yield of vines, reclamation measures for the heavier soil types, and seasonal yield variations. Crop estimates, based on the percentage of fruit buds determined by microscopic examination at the dormant stage, have been undertaken this year at the request of the dried fruits industry.

The Merbein Station has been relatively highly subsidized by organizations which benefit directly from the results of the investigations. By mutual consent, certain grants have been reduced following reductions in staff. The Australian Dried Fruits Control Board, one of the principal contributors, being agreed that dried fruits production has reached a high standard of efficiency and that the diversion of officers to work more directly concerned with the war effort is justified, has reduced its grant to approximately £600, one-third of the amount originally allocated. Minor subsidies for special investigations in the Wakool and Curlwaa districts, N.S.W., have also been reduced. The subsidy from the Mildura Packers' Association has been maintained at £1,000, principally for the work described under (6) below.

2. Soil Reclamation.

There has been an almost complete cessation of capital expenditure on agricultural drainage, by State authorities, and a marked reduction by individual landholders. The results of investigations have been published; they cover fairly completely the information required by settlers in districts where drainage facilities are available. Investigations now in progress are limited to a continuation of studies on heavy soil types giving doubtful response to agricultural tile drains.

3. Viticulture.

Estimates were made in October of the potential dried fruit crop, for the information of the industry. Maturation of sultanas was studied, and as a result it was possible to recommend early picking, thus enabling growers to make better use of the limited labour available.

The treatments were continued on long-dated viticultural trials, viz. fertilizer trials at the Station, at Red Cliffs, and at Woorinen, a pruning trial at Red Cliffs, and an oil spray trial at the Station. Yield data were obtained on the Red Cliffs fertilizer trial, and on the oil spray trial. The latter was initiated to determine the effect of a summer spraying oil, in varying high concentrations, applied during the dormant period, as a measure of frost protection. The delayed bud burst obtained gives a measure of protection from frost over the first fortnight of sprouting, but, with the higher concentrations of oil, a decrease in yield resulted.

4. Vegetable Production.

The advent of the war has expanded commercial production of vegetables and popularized production in home gardens. Suitable irrigation and cultural methods for germination of the seed and for the growth of vegetables have been practised for some years in the Murray Valley districts, and present no special difficulties, though useful minor adjustments have been necessary. There is, however, little information in reference to seasonal development, and inadequate knowledge as to the varieties best suited to the District and to the season of the year during which they are required. To obtain information on these points, monthly sowings were made, over a period of one year, of the more popular vegetables. These included carrot, parsnip, red beet, white Spanish onion, swede, lettuce, and cabbage, one variety of each being used. The data obtained include the rate of growth, obtained by regular measurement of the diameter at the largest section, a record of the seeding habit, and general observations on growth and palatability. The growth curves obtained from plants grown at different seasons of the year are proving useful in determining the optimum season for quick and satisfactory development, and the possibilities of production at off-season periods.

As in most districts, the two main crops of carrot, parsnip, and beet are produced from autumn and from spring sowings. In the Mildura district, however, these root crops grow fairly well when sown at any period of the year, though heavier crops were grown at the more favourable seasonal periods. For seed of satisfactory quality, it does not appear necessary to grow the plants at the periods of the year when the edible portion grows best . For example, a strain of lettuce (Imperial 615) quickly ran to seed after a short growing season in which the body of the lettuce developed poorly. This seed ultimately proved quite good. As selection from the off-season plants producing the seed is not possible, it is necessary to select the parent plants in the previous generation.

5. Drug Plants.

In order to determine its suitability and to gain experience in production under irrigation conditions, the Mildura district was selected as a centre for the cultivation of different types of drug plants. One variety of the opium poppy was produced in commercial quantities, and others were incorporated in variety trials; commercial production is being continued on a more extended scale. Pyrethrum has also been grown successfully in the district; it has proved a hardy plant, capable of being transplanted under summer conditions. Plots of pyrethrum and artemisia are also established in commercial quantities. Ephedra gave poor results. The drug plant programme is directed by the Division of Plant Industry.

6. Fruit Processing.

The shortage of some essential supplies required in the dried fruits industry has become more acute during the course of the war. The Research Station has endeavoured to anticipate such shortages and to have satisfactory substitutes ready in advance. The use of Australian cottonseed oil instead of imported olive oil, and of vine ash extracts instead of commercial potash, have been mentioned in previous reports.

Cottonseed oil and oleic acid, which are used in the preparation of oil emulsions for dipping purposes, are now in very short supply. Investigations carried out during the past year have shown that, in the preparation of cottonseed oil emulsions for dipping purposes, oleic acid may be successfully replaced by linoleic acid, stearic acid, or commercial "black acid" from the Twitchell process. It has also been shown that when suitably emulsified, a mixture of equal parts paraffin white oil and cottonseed oil may be used instead of pure cottonseed oil.

In response to a request from the Controller of Defence Foodstuffs, storage trials have been carried out with dried apricots to determine the suitability of various containers and the keeping quality of the fruit under service conditions in the tropics. Containers were packed and stored in the open at Merbein during hot weather, under conditions probably as severe as those usually experienced in the North. These trials showed that it is inadvisable to store dried apricots, and presumably other dried fruits, in the open in steel drums in a hot climate without protection from the sun. Under such conditions a tinplate container inside a wooden box is more suitable than an unprotected steel drum. Dry pack apricots are more suitable for storage in the tropics than moist pack apricots.

Further investigations have been carried out on the dehydration of pears and clingstone peaches. It has been shown in the case of peeled pears and peaches, that the usual sulphuring treatment (exposure of the fruit to the fumes of burning sulphur in a sulphur box for lengthy periods can be replaced by an immersion for a period of 1 to 5 minutes in a sulphite solution of suitable strength and pH. This immersion process has the advantages of being more continuous than the fume method, and requiring fewer dehydrator trays; none are needed during the sulphuring process.

Peeled and sliced pears and peaches, sulphured by the immersion method, may be dried in 10 to 15 hours overall from fresh fruit to finished product.

7. Additional Activities.

The diversion of manpower occasioned by the war has brought new problems to the dried fruit areas.

Shortage of fuel for irrigation pumping units has necessitated curtailment and alteration in the irrigation programme of various settlements.

The reduction in the quantity of fertilizers available has also necessitated alteration in routine practices. The Station is continuously in consultation with dried fruit and irrigation authorities on these and kindred problems, in the endeavour to ensure that these disabilities should affect production as little as possible.

The Station has co-operated with the Department of Supply, the State Departments of Agriculture, and the Department of the Army, in organizing the production of special products, assisting particularly in the provision for irrigation, and in the selection of suitable production environments.

B.—IRRIGATION RESEARCH STATION (MURRUMBIDGEE IRRIGATION AREAS), GRIFFITH, NEW SOUTH WALES.

1. General.

The Irrigation Research Station at Griffith was established in 1924. It has 90 acres of irrigable land, 30 acres of which are planted, and it is provided with good laboratory facilities.

The N.S.W. Water Conservation and Irrigation Commission provided the land and co-operated in the establishment of the Station and provides £2,000 per annum towards the cost of the investigations. The various settlers' organizations and co-operatives are very active, through the Advisory Committee, in their interest in the work of the Station and have agreed to increase their contribution of £100 per annum towards the cost of the investigations to £1,100 for the express purpose of bringing the results of the investigations more quickly to the irrigation community.

The work of the Station has been expanded considerably owing to pressing problems in maintaining production of fruit and increasing production of vegetables.

2. Orchard Survey.

As previously reported, detailed statistics of the fruit tree and vine plantings, including varieties and year of planting, have been published. These statistics are now being revised each year to keep them up-to-date and accurate. The statistical analysis of the data collected during this survey has been completed and the report is now in print. The Biometric Section assisted in carrying out this work.

3. Orchard Cover Crop Investigations.

The Station's long-term citrus cover crop plots demonstrated the value of lucerne in controlling excess soil moisture, salt, and structure deterioration. On these plots, however, the competition of the lucerne depressed growth and yields during the early life of the tree. Experiments are therefore being conducted to study the effect of lucerne and other cover crops on trees which have already reached maturity. These plots are located at the Research Station and on peach and citrus plantings on settlers' farms covering a wide range of conditions of soil, slope, and management. In addition to lucerne, the treatments include subterranean clover—as far as possible left uncultivated—and a winter crop of tick beans followed by summer clean cultivation. The practicability of grazing the lucerne and subterranean clover plots with sheep is being investigated.

Experiments on these plots and on some other sections of the research project farms deal with irrigation methods and technique, infiltration characteristics, salt content, soil moisture, and watertable fluctuations. Tree response is measured by health surveys, yield (including size of fruit), and the amount and distribution of roots. These are necessarily long-term experiments and, although much useful information can be obtained during their progress, no valid conclusions on the ultimate use of cover crops can be drawn for some years. Previous experience on the Research Station and settlers' farms showed that certain initial difficulties must be expected in the establishment of perennial crops or practices entailing restricted cultivation. These are associated with greater nitrogen demand, possible irrigation difficulties associated with flood irrigation of cover crops, and soil moisture deficiencies.

On three locations, high watertables associated with record May-June rains in 1942 had an overriding effect. These were all on flat land with soils of rapid surface intake, but extremely poor underdrainage. The close test-well grid on these plots enabled the watertable to be followed accurately, and it was obvious that when it rose within the root zone the trees were affected. The extent of damage was closely associated with the amount of the root zone invaded by the watertable and the length of time it remained there. Apart from the areas affected by watertable, the tick bean plots have so far shown a consistently good response. On some sites, subterranean clover and lucerne have been as good as tick beans. Where peach and citrus growth has been less on lucerne and subterranean clover plots, it appears to be associated with nitrogen and soil moisture deficiency. The same general results were obtained on the Research Station plots where these treatments and modifications of them are being studied in greater detail.

Growth, health, and other records have been continued on the 15 acres of citrus to be used as a factorial experiment embracing cover crop, fertilizer, soil moisture, tile drainage, and other treatments. This grove is now well established and in its third year. It consists of particularly uniform material, selected from the seedling stage onwards.

4. Vegetable Investigations.

The main problems of vegetable culture under the irrigation conditions of the M.I.A. are: (i) irrigation, (ii) germination of seed, particularly of carrots, and (iii) weed control. Other important questions to be answered concern fertilizer requirements, food values, seeding times, and seed production.

(i) *Irrigation.*—The application of water to vegetables presents many problems. To germinate a sown crop of vegetables, rather exacting conditions in irrigation technique are necessary. The raised beds or hills must be uniformly and sufficiently soaked without the surface of the beds coming in contact with the irrigation stream.

Detailed experiments have been carried out on the Research Station and on adjacent properties with furrow irrigation methods and with contour-bay methods of flood irrigation of vegetables. The aim has been to attain satisfactory irrigation with the least quantity of water applied, to counteract the tendency for undue waterlogging with the attendant dangers of salt accumulation and soil deterioration. The Station's experiments show that it is possible to set out irrigation furrows, with falls of as little as ¼ in. to ½ in. per chain, with the aid of suitable A-frame level of simple construction. It has also been demonstrated that successful irrigation lay-out for vegetables in the field requires smoothing of the land (instead of the more costly grading) with the furrows curved to conform with the undulations of the land. Field trials have shown that, with adequate flow rates, this irrigation technique will give the satisfactory even application of water required in

vegetable irrigation; at the same time the total quantity of water applied in each irrigation is quite light. Similar results have been obtained with the contour-bay flood method of irrigation. The factors involved have been studied and the limits defined.

The experiments have been extended to settlers' holdings with different conditions of soil types and slopes for further observation and modification of the methods. This has also enabled some assistance to be given to the settlers in their problems of vegetable irrigation.

(ii) *Germination of Seeds.*—The germination of the seeds of some varieties of vegetables, particularly carrots, is very erratic and leads to much wasted effort and expense. Investigations show that the problem is rather complex; such factors as aeration, moisture content, soil temperature, as well as unexplained effects, are all important and interrelated. Under some conditions superphosphate generally improves the germinations.

(iii) *Weed Control.*—Control of weeds absorbs a large amount of manpower, particularly in growing carrots and other root crops. A solution to the problem is being sought both by the use of mechanical means, special hoes, etc., and by the use of chemical weedicides.

(iv) *Fertilizer.*—The best fertilizer programme for carrots and cabbages is being studied by means of field experiments.

(v) *Seed.* — Attention is being given to certain plants in the production of pure seed. Trials are being conducted with seed of the more important varieties of carrots and cabbages from various sources, with a view to producing mother seed of the best type possible. Cultural problems concerning carrot seed production on a commercial scale have been investigated by field experiments.

(vi) *Nutrient Constituents.* — The effects of varieties, time and stage of harvesting, fertilizers, irrigation methods, and other important factors of growth, on the ascorbic acid, carotene, and sugar content of cabbages and carrots are being studied. Assistance in this work is received from the Division of Food Preservation.

5. Irrigation Investigations.

Under unfavourable soil and slope conditions, poor under-drainage and impeded run-off in wet periods result in excess soil moisture conditions which make it extremely difficult to grow citrus successfully. This has been shown in watertable studies, and during the year the Station has assisted in defining soil and slope suitability standards as a guide to land-use for citrus.

Experiments are in progress to determine the best methods of watering declining citrus groves. These deal with restricted area watering, including alternate bay or furrow irrigation (both allowing some portion of the soil to dry thoroughly without the tree wilting), and with the effect of various degrees of wilting on tree health and yield. A large number of infiltration tests were carried out on several soil types, and these have been used in drawing up recommendations on irrigation practice. In the Yenda district it has been demonstrated, for example, that soils of the Yenda series should be irrigated within an hour, as compared with longer permissible periods on adjacent soils of the Griffith series.

A permanent site for investigating irrigation principles has been prepared for continuing the study of furrow size and shape under controlled soil, slope, length of run, and flow rate conditions. This work is particularly important in the irrigation of vegetables and under difficult soil and slope conditions. Special irrigation investigations on vegetables and on research project farms are reported under these headings.

6. Drainage Investigations.

High watertables, for years of irrigation augmented by recurrent wet winters, have made under-drainage an important problem on the Murrumbidgee Irrigation Areas. The decline in tree health, especially citrus, over the last few years is closely related to high watertables and excessive soil moisture conditions. The problem of under-drainage is being approached in three ways.

(i) The laying of Experimental Drainage Plots under controlled conditions. Last winter one experiment was laid down on Farm 713, on a Yenda sandy loam. Records are kept of irrigation applications, drainage effluent, watertable fluctuations, salt, tree health, yields, size of fruit, and cultural operations. The winter watertable position is satisfactory and tree health has improved. This type of experiment is being extended to other soil types which will probably respond to under-drainage.

(ii) Investigations on drainage project farms where settlers have already installed drainage systems. Here similar records to (i) are kept, the influence of drains on the watertable is marked, and a favourable soil salt balance is maintained.

(iii) A survey of eleven farms where drains have been installed for varying periods under different soil conditions. The report on this survey will supply information to settlers desirous of laying drainage systems immediately.

7. Pasture Investigations.

These investigations, caried out co-operatively with the Agrostology Section of the Division of Plant Industry, had as their object the determination of the best irrigation methods for both summer and winter pastures. The information sought in the first stage of this study has now been obtained.

8. Botanical Studies.

Growth studies, root studies, citrus stock investigations, inarching experiments, and growing of various drug plants carried out at the Station are reported under the Horticultural Section of the Division of Plant Industry.

VII. FOREST PRODUCTS INVESTIGATIONS.

1. General.

Little new ground has been opened up during the year under review, the main activities of the Division having been continued as advisory to the various branches of the Services and industry, with experimental work largely confined to the solution of problems arising from day to day. Steady progress has, however, been made in those lines of investigation basal to aircraft production, such as the development of improved wood and the use of timbers for aircraft plywood other than those already approved.

A crop of problems arose in connexion with the treatment of timber to fit it for the conditions that exist in tropical areas. These have numerous aspects and are at present under investigation. New laboratories erected for paper testing work and for flax have enabled the sections concerned to work more efficiently and to concentrate their work in one area. The Division needs more room to accommodate its greatly increased staff, and plans are in hand to enable an extra storey to be provided. This will be of the utmost assistance in relieving the pressure on existing space.

There is a large field of experimental work awaiting development in connexion with newer types of synthetic resin glues and methods of plywood manufacture and use. One of the great difficulties in developing in this direction is the inability to get trained staff of the right type.

An officer of the Division has spent several months in U.S.A. studying latest developments there, and will return early in 1944. It is hoped that the Australian plywood industry will benefit appreciably by his knowledge of recent advances in plywood technology.

The following summaries of the work of the Sections set out the main lines of work during the past year:—

2. Wood Chemistry.

The Wood Chemistry Section has devoted much of its time to the continuance of the study of fundamental problems on behalf of the Australian paper industry. In addition, some time has been devoted to miscellaneous chemical and paper investigations related to the war effort.

With the increasing importance of wood, pulp, and paper in the war effort and, eventually, in post-war developments, it was only natural that frequent requests for methods of wood and pulp analysis should have been received. It was accordingly decided to take the initial steps for the setting up of standard methods. In the light of experience gained during the past five years, the methods employed by the Section have been revised and set out in a form suitable for use by the Australian pulp and paper industry. On the whole, the methods have been well received and, subject to minor amendments, it is anticipated that they will be adopted, at the next Paper Industry Conference, as standard methods for use throughout Australia.

Following the resignation of the officer working on the chemistry of the lignin of Australian eucalypts, this investigation was interrupted for a period of six months until a suitable successor was found The investigation was resumed in January, 1943.

When some pilot experiments were made on the samples that had been used earlier, it was found that the methanol extraction method for "native lignin" gave very low yields. Since it was concluded that the ageing of the wood had rendered the lignin less soluble, a new tree (*E. regnans,* 1932 regrowth at Powelltown) was obtained and a representative sample of its sapwood was reduced to sawdust. The latter was exhaustively extracted with distilled water at 50° C. and then stored under methanol until required. Methanol extraction of this sawdust at 150° C. has yielded about two-thirds of the total lignin present. Half of this lignin is water-soluble. Yields and solubility have been unaffected by drying the wood. A source of difficulty has been the precipitation of the water-insoluble lignin in a filterable form. Eventually, it was discovered that a flocculent, easily filterable precipitate could be obtained by making the colloidal suspension first alkaline and then acid. It is quite possible that the low yields from the earlier wood sample may have been due to failure to precipitate the lignin rather than to extract it. The study of eucalypt carbohydrates has been discontinued, with the consent of the paper industry, until such time as a suitably qualified officer can be obtained to continue the work.

Chemical pre-treatment of battery separators has been investigated during the year. The study has been concerned mainly with the occurrence and removal of manganese from separator stock. It was demonstrated that a recommended alkaline pre-treatment could not ensure that the manganese content was reduced to a safe level. In fact, the alkali proved to be most ineffective in removing mineral matter. Of the woods examined, only Queensland kauri contained manganese in amounts which might be regarded as serious, but it was established that, if the alkaline treatment was followed by soaking in cold 10 per cent. sulphuric acid for 24 hours or in boiling 1 per cent. sulphuric acid for 1 hour, and then by washing in cold running water, the manganese content was reduced to less than 2 mg. per 100 grammes of wood. This result could be obtained no matter what the manganese content of the untreated wood.

In conjunction with several other departments, investigations were carried out to improve the water-resistance of chip-board containers, used for specific purpose. In an effort to develop a suitable substitute for rosin as a paper-sizing material, experiments were made with Xanthorrhoea resin (blackboy gum). In concentrations up to 1 per cent. in pulp, this material was shown to be almost as effective as rosin, but its sizing properties did not improve above this concentration.

Minor investigations have included the following:

(i) Reasons for the failure, at the cream line, of milk containers made from Australian paper as compared with those made from English paper. The chief difference between the papers was shown to be in the mineral loading, the English paper containing a large amount of calcium sulphate.

(ii) Examination of "floss" from *Cryptostegia grandiflora* with a view to its possible utilization as a source of alpha-cellulose. Attention was drawn to the water-repellent properties of this material.

Methods of pulp evaluation have been actively investigated during the year. The study of variables in operating the Lampen mill has recently been concluded by the consideration of various other pulps, some of which are now in common use in Australia. It is anticipated that the results of this study will shortly be implemented. Messrs. Australian Paper Manufacturers Ltd. have authorized the setting up of a permanent Pulp Evaluation Committee within the Company. This committee proposes to adopt a standard procedure recommended by the Section. When adopted, this procedure will be adhered to in all the company's laboratories where Lampen mill evaluations are made. One of the committee's functions will be to ensure strict adherence to the standard procedure. Amendments to the procedure will be made only on recommendations submitted by the Section and based on experimental evidence.

Various other aspects of pulp evaluation procedure have been examined during the year. The Section has succeeded in developing two types of apparatus for mixing and sampling pulp stock for freeness tests and sheet-making. Investigations have shown, by their use, that stock may be sampled with a much higher degree of precision than is normally obtained. It is anticipated that one or other of these instruments will be adopted by the industry for use in both laboratory and mill testing.

Other investigations have been concerned with the variation within a stack of sheets as the result of pressing, and the number of sheets that may be pressed simultaneously. It has been demonstrated that any number of sheets, within the capacity of the standard press, may be pressed simultaneously. However, there is a distinct trend in sheet properties with position in the press, and it seems very desirable that, other things being equal, the lowest sheet in the stack during the first pressing, and possibly the

uppermost sheet as well, should be excluded from testing in work where a high degree of precision is required.

A search has been made for possible causes of the characteristic phenomenon in eucalypt kraft sheets, known as "skinning" or "peeling," during tear testing. Consideration of the influence of blotters, couch rolling, method of stacking in the press, the glazed press plates, and of pressure, has failed to reveal the cause of this phenomenon. It must be concluded that it is an inherent characteristic of eucalypt kraft caused by the lack of lateral adhesion between felted fibres within a sheet. During the course of this study it was revealed that both bursting strength and bulk are proportional to the logarithm of the pressure employed, the regression of each of these properties on log (pressure) being lineal within the 99 per cent. probability range.

The influence of water supply and, in particular, of dissolved salts on the Canadian standard freeness determination has received a considerable amount of attention during the year. The results reveal the futility of placing much faith in freeness values, except for mill control, where a particular pulp, sizing material, and water supply are concerned. The influence of Mullen Tester diaphragm thickness on bursting strength was examined, and it was shown that, within the range of thickness studied, *i.e.*, within the range of a trial order supplied by an Australian manufacturer, diaphragm thickness had no significant influence on the bursting strength values.

Some investigations have been carried out with the object of finding ways of increasing the number of tear readings per set of pulp hand sheets. A suitable procedure has possibly been developed whereby nine readings instead of three, each on four plies, may be obtained for each set of six pulp hand sheets.

The accuracy of basis weight determinations has also been examined. It has been shown that pulp hand sheets invariably spread during pressing, and their area is larger than that normally assumed (200 sq. cm.). The template method is also inaccurate, as well as being very variable. Sufficient data have been collected to permit a more accurate calculation of sheet area at any beating point for pulps most commonly used in Australia.

3. Wood Structure.

(i) *Investigations of Structure in Relation to Properties.*—(*a*) In the testing of aircraft quality plywood made from different Australian timbers, it has been observed that in some cases the shear properties were particularly poor. Certain experiments were accordingly designed to investigate the possible relation between this fact and the anatomical structure of the timbers in question. For these experiments, $\frac{1}{16}$ in. veneer, cut from each of a dozen different species, was laminated into $\frac{3}{4}$ in. boards (veneers from the one species only in each board and all veneers in the one direction). From these boards shear specimens were cut and tested, both parallel to the laminations and perpendicular to them. Microscopic examination of sections cut through the failures revealed that there was a definite tendency for the failure to be related to a particular structural feature in any one species. These observations are being continued, using solid shear specimens from the same timbers.

(*b*) During the year, particular attention has been paid to the examination of all test specimens of silver ash and silver quandong, two species used as aircraft timbers, to determine the relationships existing between structure and properties in each case. In both species little or no reaction wood was found and the amount of brittle heart observed was not great. Silver quandong was somewhat prone to compression failures, and the specimens containing these failures were examined extensively. The area of brittleness in these specimens was restricted to the close vicinity of the failures, and the wood between the various failures was normal.

(ii) *Reaction Wood.*—Further information concerning reaction wood and its properties has been collected during the year. The influence of tension wood on the properties of bollywood has been investigated, and it was found that the tension wood occurred in narrow oblique bands (not paralleling the grain) alternating with bands of normal wood.

Four out of five trees examined showed this tension wood, although it was not easy to detect macroscopically. From the observation of both slip planes and numerous minute compression failures in the tension wood, it has been concluded that these features are developed in the living tree and are not a result of subsequent treatment of the wood. Tension wood areas have also been recorded in specimens of silver ash, in shining gum, and in a number of specimens of locally grown willow. In the willow, these areas were sufficiently pronounced to prevent the utilization of the logs for match splints.

Difficulties have been encountered in the macroscopic detection of compression wood in both hoop pine and King William pine, two timbers utilized in aircraft construction and from which it is essential for compression wood to be eliminated. Some 6,500 examinations of boards have been made, and microscopic methods had often to be utilized to detect compression wood with any certainty. However, with this experience it is now possible to separate the large majority of boards containing compression wood by macroscopic means. Further experiments have been carried out using the method of detection developed by the U.S. Forest Products Laboratory (viewing of thin cross-sections against a strong source of light); these showed that the method was 80 per cent. effective with hoop pine, but considerably less effective with King William pine.

(iii) *Identification Work.*—In addition to 4,000 identifications made for the Section of Timber Mechanics in connexion with their specification work on aircraft timbers, a further 275 have been carried out during the year for various outside bodies. Other interesting and important identification problems have been related to specimens of wood flour where it was necessary to have some idea of the constituent timbers; samples of wood shavings; numerous paper samples where reports on the identity of the fibres present were required.

(iv) *New Guinea Timbers.*—During the year this Division has been approached by the various Services for the information available on New Guinea and Papuan timbers. It will be realised that very little definite information on the timbers of these regions was available before the war, since only relatively few species had reached Australian markets. However, the Division has undertaken to prepare material on a large number of timbers which have been selected as most common in occurrence and likely to prove most useful. In the preparation of the data, reference has, of course, been made to Lane-Poole's "Forest Resources of New Guinea" and also to records and publications concerning the timbers of the Dutch East Indies, the Philippines and other Pacific Islands. Many of the important species of New Guinea and Papua have more than a local distribution and it has therefore been possible to obtain useful information concerning them.

(v) *Structure of Improved Wood.*—Other investigations on the manufacture of improved wood under

varying conditions and using various types of phenol-formaldehyde resins have been assisted by the examination of the structure of the improved woods so obtained. This structural examination has also been extended to improved woods manufactured commercially and those made in the laboratory, but using commercial resins and tego film. The effect of altering certain conditions of manufacture, *e.g.*, pressure used or amount of resin employed, can be readily detected in the structure of the product. One important observation was a definite difference in general appearance when lightly condensed resins as opposed to more advanced resins were employed. With the latter type the resin is observed in the cell cavities, whereas with the former type there is apparently a greater penetration of the cell wall, since resin is not prominent in the cell cavities. By examination of structure it was therefore possible to obtain some idea of the degree of advancement of resin employed in the manufacture of the improved wood.

(vi) *Fibre Examinations.*—Kraft pulp from *E. regnans* has been examined microscopically at various stages of beating in the Clark-Kollergang laboratory beater and compared with similar pulp beaten to a comparable degree on the Lampen mill. Certain differences in fibre characteristics were noted, and these were apparently related to the method of beating employed.

(vii) *Photography.*—With the increased activities of the Division, and with the handling of negatives from the Australian Scientific Liaison Office, London, and other work for Head Office, the photographic work has again increased considerably.

4. Timber Seasoning.

(i) *Aircraft Timbers.*—The development of kiln schedules for aircraft timbers remained one of the major projects of the Section throughout the year. Twelve kiln schedules for a further three species were finalized, and these were released for use in the commercial kiln drying of aircraft timbers. To date work has been completed on eight aircraft species, namely, alpine ash, mountain ash, King William pine, Queensland maple, hoop pine, northern silver ash, Queensland silver ash, and silver quandong. Work on two further species, namely, white birch and sassafras, is still in hand.

Supervision of the commercial seasoning of all aircraft timber kiln-dried in Victoria for the Department of Aircraft Production, which was undertaken at the request of the Department, and which involves the testing and certification of all material for final moisture content and stress condition, was continued. Many thousands of super feet of various species were dried and forwarded to the Department of Aircraft Production stores during the current year.

The preliminary selection of all timber supplied from mills in Victoria to aircraft requirements, was also continued by an officer of the Section on behalf of the Department. To accelerate the grading, resawing, and seasoning of Australian and overseas aircraft timbers in N.S.W., plans for the construction of a new timber seasoning annexe were prepared.

(ii) *Rifle Furniture.*—Supervision of the drying and treating of all rifle furniture at the only munitions annexe of this nature in Australia, and the maintenance of timber supplies at this plant, was continued, one officer giving his full-time attention to this work.

(iii) *Food Dehydrating.*—By virtue of experience gained in the design of drying units generally, the Section was able to give considerable assistance to various authorities responsible for the construction of food dehydrating equipment. In particular, at the request of the Food Production Committee, U.S. Army Services of Supply, a design was prepared for a progressively operated blanching unit; advice was also given on the construction of a food dehydrating plant at present in course of erection in Melbourne for the Australian Government; experimental work was carried out to determine the most suitable life of the Australian timber species for drying trays, and the avoiding of staining or sticking; and experimental kilns were made available to test the suitability of various surface finishes for metal drying trays.

(iv) *Naval Life-Saving Rafts.*—On behalf of the Navy Department, work was carried out to determine a suitable material for life-saving rafts in place of balsa, an extremely low density South American wood which is normally used for this purpose, but is now in short supply in Australia. The experimental work indicated that an excellent float can be made from pressed granulated cork (prepared from cork waste) faced with resin-bonded plywood to give greater mechanical strength. Even after full submersion in water for over 3½ days, no breakdown occurred in the float construction, and the density increased from 10.3 lb. per cubic foot to only 11.78 lb. per cubic foot. The tests indicated that the construction produced an apparently unsinkable life raft, for which the buoyancy is little affected by damage to the outer facing. In service, bomb or bullet damage should not affect the serviceability of the raft.

(v) *Army Equipment.*—At the request of the Army Design Directorate, and in association with the Veneer and Gluing Section, an instrument box capable of reasonable life under tropical conditions was developed from hot-press resin-bonded plywood. Urea resin glue was used in the box constructional joints. No failure occurred in the box during testing under simulated tropical conditions. The work was instituted because of the rapid deterioration of instrument boxes of standard construction in tropical conditions. An under-surface roof coating, to prevent the formation of condensate on the inner surface of the metal roofing of military hutments and stores during cold weather, was developed at the request of the U.S. Army. Satisfactory results were obtained with sawdust and bitumen emulsion sprayed simultaneously on to the metal to a depth of about $\frac{3}{16}$ in. or so. The dark appearance can be improved by a final spraying with lime wash or other material of that nature. The equipment and experience of the Section was utilized from time to time for testing, under high temperature high humidity conditions, aircraft equipment, tank equipment, and other electrical gear.

(vi) *Other Activities.*—Work was carried out on Queensland lawyer cane to determine whether it could be kiln dried satisfactorily and utilized as a substitute for the rapidly decreasing stocks of Java cane. It was found that, with proper selection, the lawyer cane made a satisfactory substitute. It is now being used in the construction of sporting goods for the Army.

A fairly large part of the time of the Section was taken up in the preparation of designs for timber seasoning kilns. Designs for approximately 30 installations were issued during the year. A number of special designs were prepared, among which were those for a laundry drier for drying the field equipment and clothing, etc., of military personnel located in the north of Australia.

It is of interest to note that there are now some 800 timber-drying units in Australia. Of these, 616, with an estimated annual output of 300,000,000 super feet of timber per year (1-inch basis), are on

solid timber, 91 are used for the drying of veneer or redrying of plywood, 55 are used for redrying timber for corestock or for conditioning veneer, and the remainder are either special types or laboratory kilns. Advice on the modification of existing kilns so as to obtain more efficient service was also given. Kiln tests carried out during the year emphasized the importance of this work to the timber industry of Australia. The inefficiency that can result if kiln design is left entirely in hands of unskilled private enterprise was amply demonstrated during the year.

Assistance was given in solving certain manufacturing difficulties which developed during the early stages of battery separator veneer production in Australia.

The correspondence courses conducted for the training of kiln operators were continued; a further 23 students have commenced study. Since the inception of the courses, some 215 students have been enrolled. Of this number 63 per cent. have completed the preliminary section and 16 per cent. have completed the full course of 23 lessons.

The usual contact with the timber trade and the public generally, per medium of the usual minor enquiries received, was maintained.

5. Timber Physics.

(i) *Physical Properties of Australian Timbers.*—Detailed investigations are being made of the shrinkage and the density of the more important Australian timbers. These studies include the variation of these properties with position in tree, and the effect on them of the presence of reaction wood. About 24 species have already been covered. Fundamental shrinkage studies have been made to determine the part played by the medullary rays in wood on the overall tangential and radial shrinkages. The evidence obtained contradicts statements recently published on this subject, and a criticism of these statements has been prepared. Work is in progress on the thermal expansion of both normal wood and improved wood.

(ii) *Relation Between Silviculture and Physical Properties.*—As opportunity permits, the series of tests begun about three years ago on behalf of the Queensland Forest Service is being completed. Recent work has concerned the shrinkage and density of plantation-grown cypress pine, loblolly pine, and hoop pine.

(iii) *Moisture Content Relations of Plywood.*—It has been shown that the equilibrium moisture content curves for plywood are influenced to a large extent by the type of glue used. Absorption and drying equilibrium curves have been determined for the principal types of glue. Methods of determining the moisture content of plywood have been examined in detail.

(iv) *The Effect of High and Low Temperature on the Strength of Wood, Plywood, and Glued Joints.*—The first part of this work, namely, that on material at 15 per cent. moisture content, has been completed, and the investigation is now being extended to other moisture contents.

(v) *Battery Separators from Australian Timbers.*—Following preliminary investigations to determine the suitability of various Australian timbers for battery separators in place of imported Port Orford cedar, the more promising species have now been subjected to accelerated life tests. The results have shown that properly selected and treated Queensland kauri and hoop pine can be used with confidence. Australian Standard Specifications have now been promulgated to cover the manufacture of Australian timbers for various types of batteries. The majority of separators are now made from Australian timbers, mainly hoop pine and kauri. Other suitable timbers are celery top pine and King William pine, the latter for stationary batteries only.

(vi) *Compressed Wood.*—Experiments have been commenced on the manufacture and properties of compressed wood (lignostone), but owing to the demands on the press for other work only slow progress is being made.

(vii) *Miscellaneous Investigations.*—At the request of the Housing Commission of Victoria, a comparison is being made of the heat insulation of the standard brick construction and a cheaper type of prefabricated concrete construction. Two types of tests were undertaken, the first involving the measurement of the heat required to maintain a constant temperature, and the second being merely the continuous recording of the temperatures in similar houses which are occupied. The first test has already been completed and the second will be concluded shortly.

6. Timber Mechanics.

(i) *Munitions Boxes.*—Close liaison has been maintained with the Directorate of Explosives Supply, the Factory Board, Timber Control, the Army Design Directorate, and numerous box manufacturers with regard to the design and construction of boxes and crates for all types of munitions. Attention has been paid both to the design of boxes for new purposes and to the re-design of existing boxes in order to save labour and material. Whenever possible, the cleated plywood type of construction has been adopted as standard, because it reduces the quantity of timber per box by about 50 per cent., and, provided that it is properly designed and constructed, it is stronger than the conventional type of box. Overseas practice is to nail the plywood to the cleats but, on the recommendations of the Division, in Australian-made boxes, the plywood is glued to the cleats, thus making a stronger and generally more satisfactory container.

(ii) *Timber Structures.*—Timber is now the standard material of construction for munitions factories, stores, hangars, etc., steel being used only if it is impracticable to use timber. Some of these structures are very large, and their design and construction were greatly facilitated by the data obtained by the Division during the last 15 years and published in the "Handbook of Structural Timber Design" and Supplement. This Handbook is now universally regarded by engineers and architects as the standard reference book on the design of timber structures and has been specified as the legal authority on working stresses for timber in the draft "Uniform Building Regulations for Victoria," which has just been published. These Regulations also specify the Division's pamphlet on "Building Frames" as the authority for determining the size of timbers to be used in domestic buildings.

Probably due to the universal use of green timber of comparatively poor quality, certain troubles, due to "creep" of the timber under long continued loads, have manifested themselves in a number of these buildings, resulting in excessive deflections and, in some cases, structural failures. Very little is known about the effect of long-continued loading of timber, and methods of overcoming the troubles encountered have necessarily been largely empirical, based on a few tests made by the Division before the war. However, the problem is of such importance that it has been decided that large-scale systematic investigations should be made on (*a*) the phenomenon of "creep" in timber, and (*b*) the effect of long-time loading on the strength of timber joints.

These tests are now being planned, and to study "creep" it is proposed to carry out long-time loading tests on specimens of mountain ash over a range of stresses from 250 to 3,000 lb./sq. in. in compression and from 1,000 to 5,000 lb./sq. in. in tension. The loads will be applied by springs and the strains will be determined by measuring microscopes. The specimens will be kept in air-conditioned cabinets at a constant temperature of 95° F. Specimens will be tested at three moisture contents (green, 25 per cent., and 14 per cent.), the humidities in the cabinets being maintained at the appropriate levels. It is intended eventually to investigate the influence of such factors as variations in moisture content and temperature, and the species of timber.

The effect of long-time loads on the strength of timber connector joints is also being investigated. Recently, a number of failures have occurred in the tension joints of Pratt roof trusses. The trouble first manifests itself as an end-split which gradually widens until failure may occur some months after erection, under dead loads only. Analysis of the failures indicates that with green hardwood the strength of timber connector joints is very much lower than was expected from previous tests which were all made with short-time loads. Preliminary short-time tests showed that an end-split caused by drying stresses can produce an appreciable reduction in the strength of the joint. However, the provision of a stitch bolt brings the strength back practically to normal. These tests also indicated that to develop the full strength of the joint in green hardwood the end distance for a 2½ inch ring should be 8 inch rather than 5½ inch as recommended by American authorities for Douglas fir.

It is proposed to investigate the various factors involved by long-time loading of a considerable number of joints, since the preliminary short-time tests showed that the great reduction in strength experienced in practice could not be reproduced in the laboratory by short-time loading. The loads will be applied by bolts and hand-operated nuts, the loads being determined by measuring the previously calibrated bolts by means of strain gauges.

As mentioned previously, the quality of timber being used in most of the structures now being built is very poor. The proper grading of all structural timber has been strongly advocated, unfortunately with little or no success. It is impossible to design structures rationally unless the timber is graded, and it is considered that the extensive use of ungraded timber will cause unduly high maintenance costs and under some circumstances may be responsible for serious structural failures.

(iii) *Aircraft Timber Investigations.*—(*a*) *Solid Timber.*—About 33,000 tests (exclusive of moisture content determinations) were made during the year. The testing of northern silver ash and silver quandong was completed. The analysis of the results of the tests on the various species so far investigated was continued, and design stresses for hoop and bunya pine and King William pine were issued.

An investigation on the Izod tests has shown that, at any rate in the tougher timbers, the notch has no effect on the results obtained or, in other words, an unnotched specimen will give identical results with a notched specimen of similar size. Further tests will be made on brittle timber to check this conclusion, but it would appear that the standard Izod specimen is unnecessarily elaborate, and that considerable savings in man-hours in the preparation of the specimens would be made if the notch were eliminated.

Rate of loading tests in compression parallel to the grain have shown that in Australian timbers the increase in strength with rate of loading is much less than the figure given by the U.S. Forest Products Laboratory for spruce. This has been taken into account in drawing up design stresses for Australian aircraft timbers.

(*b*) *Specification Tests.*—At the request of the Department of Aircraft Production, specification tests are made on all Australian-grown aircraft timber used in Victoria. Many thousands of super. feet per month are tested in this way, entailing a total of about 125,000 tests during the year. A considerable amount of time was devoted to analysing these results and also the results obtained by other laboratories doing similar work. Because of the large number of specimens tested, it is possible in this way to obtain much more precise information on certain of the properties of the species concerned than can be gained from the necessarily limited amount of timber tested in the research programme.

(*c*) *Veneers and Plywood.*—In co-operation with the Division of Aeronautics, tests are being made to determine the strength and stiffness of veneer of different species at varying angles to the grain. Such information is required in the design of stressed plywood portions of aircraft. The results so far obtained check the theoretical values very closely.

With the increasing use of wooden aircraft in which stressed plywood is extensively used, detailed information on the properties of plywood is urgently required. Systematic tests are being made on the effect of moisture content on the properties of plywood—an important subject on which there is very little information.

The strength and elastic properties of plywood panels subjected to shearing stresses are being investigated, the apparatus used being identical with that adopted by de Havillands, so that the results obtained by the Division may be directly comparable with those obtained by that firm. It has been found, by the use of electrical strain gauges, that the stress distribution across a plywood panel in shear is anything but uniform, and it is anticipated, therefore, that the strength and elastic properties of the plywood panel will vary with the size of the panel.

A satisfactory method of measuring the compressive strength of plywood, using a number of pieces clamped together at the ends, was developed. Routine tests have been made on a number of species to determine their suitability for use in aircraft. Hoop pine, which is the commonest Australian plywood timber, has been found to have very favourable static strength properties in relation to its density. However, its impact strength and pliability are low. It should be very valuable in the many parts of aircraft where high impact strength or pliability are not required. A draft specification for aircraft-quality hoop pine plywood was prepared by the S.A.A.

Other timbers, such as brush mahogany, silver ash, and myrtle beech, have been found to have sufficiently good properties to be used in aircraft, but the eucalypts have proved disappointing, owing to the difficulty of obtaining satisfactory adhesion with waterproof resin glues. Also, a short series of rotary cut mountain ash and alpine ash gave very disappointing results, the mechanical properties being comparatively poor. It is possible that sliced veneer would give more satisfactory results.

Service tests on leatherwood, which had been found to have excellent properties, showed that this species has very considerable promise and a full-scale commercial test was arranged. However, the logs obtained were generally of poor quality and the recovery of aircraft plywood was very low. It

appears that, if this timber is to be used commercially, great care will have to be taken to select logs of satisfactory quality.

(iv) *Felloe Manufacture.*—Following the development of a glued laminated felloe for army general service wagons, the Division was requested by the Ordnance Factory to manufacture 2000 felloes to cope with the demand while the Ordnance Factory was being equipped for production. This work was satisfactorily completed.

7. Wood Preservation.

Much advisory work has been carried out during the year on behalf of the various fighting services and governmental departments. Problems dealt with included termite damage of different kinds, marine borer infestations, mould growths, fire hazard, and others. Recommendations for termite control, mould control, and marine borer control have been issued to the Army.

Experimental work has been commenced on the production of plywood that will be resistant to marine borers. An investigation has been commenced on the resistance of tego-bonded plywood to marine borer attack. A similar investigation into the immunity of tego-bonded plywood to lyctus attack is also in progress.

Inspections have been made of the pole test sites in Victoria and New South Wales. In all these tests the poles treated over truewood show a marked advantage over the untreated controls. Creosote-impregnated poles in general show no sign of breakdown; poles treated with inorganic salts are suffering from decay.

Assistance and advice have been given to the investigator studying the problem of pin-hole borer attack in salvage-felled timber in Victoria.

8. Veneering and Gluing.

(i) *General.*—During the year, the scope of the work of the section has been changed, improved wood investigations being transferred to the Wood Structure Section. The Veneer and Gluing Section is now in a position to concentrate on immediate problems affecting the use of plywood for defence purposes. Technical data on plywood, and particularly on water-resistant synthetic-bonded plywood, are in greatly increased demand for aircraft and various marine craft. The project naturally resolves itself into two components, the preparation of suitable veneers, and the development of methods of gluing. Both aspects are being actively investigated by the Section at present.

Anticipating increasing use of moulded plywood, the officer-in-charge of the Section has spent several months in America investigating latest technical developments.

(ii) *Veneering of Australian Timbers.*—During the year, veneer has been peeled from alpine ash (*E. gigantea*), blackbutt (*E. pilularis*), karri (*E. diversicolor*), mountain ash (*E. regnans*), spotted gum (*E. maculata*), shining gum (*E. nitens*), brown alder (*Ackama muelleri*), bollywood (*Litsea reticulata*), hoop pine (*Araucaria cunninghamii*), myrtle beech (*Nothofagus cunninghamii*), scented satinwood (*Ceratopetalum apetalum*), turpentine (*Syncarpia laurifolia*), willow wattle (*Salix* sp.).

Defence requirements make the exploitation of all suitable veneer supplies essential, and the chief veneering experiments have been in connexion with species which seemed promising for various reasons, but which were not generally produced commercially. Of these, the eucalypts, for reasons of high strength and availability, are most important. Karri (*E. diversicolor*), received recently from Western Australia, has shown possibilities as rotary-cut veneer. Results of investigations of problems of peeling and plywood manufacture from karri are to be used as the basis for establishing the plywood industry in Western Australia. Rotary-cut mountain ash has been found to be a satisfactory substitute for imported aspen for match splints, and is now being used for this purpose, following the manufacturers' adoption of necessary adjustments to their peeling machinery. Peeling of spotted gum (*E. maculata*) and blackbutt (*E. pilularis*) is also being investigated, but the formation of fine cracks in the latter during peeling is still a difficulty.

Myrtle beech, (*Nothofagus cunninghamii*) was peeled at the request of a company commencing plywood manufacture in Tasmania. Information on peeling and drying technique derived from this work was subsequently used by the Company, who also received considerable advisory assistance.

Routine peeling of scented satinwood and hoop pine has been continued for use in this Division and in the Division of Aeronautics. All other species peeled without difficulty, with the exception of bollywood (*Litsea reticulata*) and willow wattle (*Salix* sp.) which proved unsuitable through the presence of tension wood.

(iii) *Gluing of Australian Timbers.*—Gluing investigations have been centred largely on synthetic adhesives, which are becoming increasingly important, Work on the locally-produced film adhesive has been continued; in conjunction with the Division of Industrial Chemistry, mechanical and chemical factors have been investigated at the plant and at the laboratory. Very shortly, an Australian firm should be in a position to supply the entire Australian requirements at their present estimate. The Section has also co-operated with the Division of Industrial Chemistry in the project of developing a low temperature liquid synthetic adhesive, which is showing encouraging results.

The use of synthetic adhesives for eucalypt veneer is being investigated. As might be expected, with several species (blackbutt and karri for instance) excellent bonds are obtained with the urea (acid-catalysed) adhesives, but results with phenolic (and cresylic) films are less conclusive. Karri, however, is a notable exception, in that exceptionally high shear-strength values have been obtained with tego. Contrary to general belief, high strengths have been obtained at relatively high (12-16 per cent.) veneer moisture contents; exceptionally strong ply can be produced by pressing at relatively high pressure and moisture content. Spotted gum, though to a lesser extent, also shows promise with hot-pressed phenolic film.

In addition to long-term experiments, numerous short tests have been conducted on problems of gluing technique and manufacture at the specific request of various government and commercial bodies. Noteworthy among these were the solving of difficulties in bonding metal to impregnated fabric for vital parts of aircraft.

9. Timber Utilization.

(i) *General.*—During 1942-43, the work of the Utilization Section was devoted almost entirely to problems associated with the utilization of timber for munitions, and for essential requirements of the Services and civilian population. The items listed below disclose the general nature of enquiries received during the year. They were numerous and it was impossible, in many instances, where it seemed that guidance only was needed, to go further than make recommendations to overcome the difficulties. The type of problem presented was generally similar to that of the previous year, but, with the extension of activities in New Guinea, requests have been

received for advice and information on the "tropic-proofing" of wood. Frequently, the lack of an intimate knowledge of the service conditions made it difficult to tender advice which might be applicable in the field, and it soon became obvious that a survey of the conditions and service requirements was necessary before some of the problems could be solved satisfactorily. Arrangements have been made by the recently formed Scientific Liaison Bureau for such a survey to be made.

(ii) *Liaison.*—Liaison with Australian Government Departments, including Navy, Army, Air, Munitions, Supply and Shipping, and Interior was maintained, as was also contact with the U.S. Forces in Australia. Information was supplied to the Australian Advisory Committee on Aeronautics, Army Design and Experimental Directorate, Army Inventions Directorate, Navy, Army and Air Inspection Branches, Controller of Timber, Ordnance Production Directorate, Foodstuffs Committee, Contract Board, Department of Aircraft Production, Trade and Customs and others.

(iii) *Conferences.*—The Section was represented at conferences on portable prefabricated huts, charcoal and producer gas, wooden aircraft construction, hot press plywood construction, estimated requirements of logging conversion, woodworking machinery from overseas, revision of aircraft timber standards, the preparation of emergency standards for battery separators and marine plywood, and the standardization of flooring profiles.

(iv) *Advisory Work.*—Advice has been given to enquirers seeking information for timbers for the manufacture of 72 different articles, including agricultural machinery, aircraft-timbers and plywood, ambulance stretchers, assault boats and various other types of boat, battery separators and boxes, bridge and wharf construction, cable drums and reels, clog soles, crayfish boiling vats, derricks, dockyard construction, instrument tripods and cases, lapping sticks, mining timber, moulded plywood, picking sticks, pickling vats, pike poles, portable prefabricated huts, propellers, radio direction-finding equipment, refrigerators for blood banks and food, shuttles, slide rules, slipways (marine), teasing rollers, tent pegs, textile rollers, trays for dehydration of foodstuffs, wheels for industrial trucks, perambulators, &c., wooden tubs and buckets, and woollen mill equipment.

(v) *Secretarial Duties.*—The secretarial work of the Timber Sectional Committee of the Standards Association of Australia was maintained and secretarial services were provided for a Committee set up by the Department of Aircraft Production as the "Technical Sub-Committee on Timber." When this Committee was abandoned and replaced by a newly constituted Timber Panel set up by the Australian Advisory Committee on Aeronautics to perform a similar function, the same officer was again appointed Secretary.

(vi) *Specifications and Modifications of Design.* – A number of specifications for wooden articles or components of wooden articles were written or modified to meet Australian conditions. These specifications refer to types of timber to be used and their quality. Laminated construction was suggested in appropriate instances, especially when it would be impossible to obtain immediately seasoned timber in the large dimensions which were required. Suggestions were made for the modifications of design of wooden components of various articles to facilitate their manufacture with a smaller number of operations.

(vii) *Interstate Visits.*—An officer visited Tasmania in connexion with the production and utilization of timber for munitions and essential requirements. Some time was spent in Sydney investigating the aircraft plywood industry and supervising the preparation of leatherwood plywood for service trials. A survey of the veneer and hot press plywood plants in N.S.W. and Queensland was made with reference to the requirements necessary to enable expansion of production of waterproof plywood to meet demands by boat-and-shipbuilding and aircraft construction programmes.

10. Flax Processing.

(i) *Water Retting.*—Investigations have been continued, both in the laboratory and at the mills, to determine the best conditions of retting Australian flax with regard to yield and quality of fibre produced. Some of the factors being considered are temperature, water changes, and purity of water. From the results of this work, recommendations have been made which will effect substantial savings in the supervision of the retting, in boiler attendance, and some saving in water as compared with the standard overseas method previously used. The effects of the time of harvesting and of storage of flax on the retting and on the yield and quality of the fibre produced have been studied. It would appear that harvesting could, with advantage, be carried out at an earlier stage than at present. The new retting plant at Latrobe was started and instructions given in the operation of the tanks. Some preliminary attempts have been made to accelerate the water retting by the addition of small amounts of chemicals to the liquor. Retting times have been halved by the use of 2 per cent. superphosphate, for instance, but the work is not sufficiently advanced to be able to report on the economic feasibility of such a process.

Co-operation is being provided in the flax field trials being made by the State Departments of Agriculture in Victoria, South Australia, and Tasmania. These trials include varieties, time of sowing, method of sowing, rate of sowing, fertilizers, and crop rotations. Samples from each experimental plot are sent to the laboratory for retting and fibre evaluation.

(ii) *Chemical Retting.* — Following considerable success with this method of retting on a laboratory scale, it was decided to install a semi-commercial plant at Ballarat. This plant has been in intermittent operation for the last few months.

(iii) *Dew Retting.*—With recent developments in the harvesting of flax, whereby the straw is spread for retting at the same time as it is cut, the question arises as to the effect of retting under summer conditions on the quality of the fibre produced. An investigation of this problem has been made, and the results are now being analysed. Other dew retting tests on hand include the effect of storage of retted flax on the yield and quality of fibre obtained.

(iv) *Fibre Tests.*—Further work has been carried out on the use of physical and chemical tests for the evaluation of fibre quality. There is a real need for methods of grading fibre which are independent of the personal factor, and some progress towards this end has been made.

(v) *Drying of Straw.* — Further tests on, and improvements to, commercial flax driers have been effected.

VIII. FOOD PRESERVATION INVESTIGATIONS.

1. General.

During the period under review, the work of the Division of Food Preservation and Transport has been almost entirely devoted to problems of direct importance in the war effort. The canning and dehydration of foodstuffs remain the most important fields of investigation for the Division.

The amount of advisory and extension work undertaken has increased considerably. Close liaison exists with the fighting forces, the Department of Commerce and Agriculture, and the Department of Supply and Shipping, and many problems have been referred to the Division by these Departments for advice or investigation. Advice and assistance has also been given to many food processors. Several schools of instruction in the technology of canning and dehydration have been conducted at the Homebush laboratory during the year. Those attending these schools have included inspectors of the Department of Commerce and Agriculture, officers of the Department of Supply and Shipping, Army supply officers, and vegetable dehydrator operators. Further schools have been requested and will be arranged as soon as possible. The *Food Preservation Quarterly* has been continued and its circulation has much increased during the year.

A further extension to the laboratory is under construction. This will house equipment and provide additional space necessary for a greatly expanded programme of work on the dehydration of foodstuffs.

The work of the Division has again been greatly assisted by help in money, personnel, and facilities by many outside bodies. The Australian Meat Board, the Sydney Metropolitan Meat Industry Commissioner, the Queensland Meat Industry Board and the Egg Producers' Council have again given very substantial financial assistance. Generous donations from Messrs. Alfred Lawrence & Co. Ltd., Messrs. W. Angliss & Co. Pty. Ltd., and Messrs. Lewis Berger & Sons have enabled the Division to buy specialised equipment of very great value in its work.

In April, 1943, the Chief of the Division left Australia to visit North America in order to attend several conferences and to collect information bearing on all aspects of the work of the Division. The Officer-in-charge of the Canning Section of the laboratory is also visiting America.

2. Meat Investigations (Brisbane).

(i) *General.*—This laboratory continues to give much technical assistance to various food industries. The amount of consultation work, and the number of minor investigations resulting therefrom, have increased, so that they now occupy a major part of the laboratory's activities. Close liasion exists with the Defence authorities and various Commonwealth and State Government Departments, and requests for advice and technical assistance are frequently received from representatives of various food industries or related undertakings.

(ii) *Building and Equipment.* — The special electrical installation mentioned in the last annual report, has been extended to supply 240 volt power to all parts of the laboratory. New equipment has been designed, constructed, and calibrated, much of it being required for investigations on dehydration.

(iii) *Frozen Packaged Boneless Beef.* — Many contracts have been executed by Queensland meatworks for frozen packaged boneless beef, using a method which is, in effect, a simplification of that evolved by the Division for similar beef destined for use by the British Admiralty. For purposes in and around Australia, some of the packaging requirements for the Admiralty shipments were unnecessary. The wooden case employed holds about 60lb. of beef, is unlined, and is simply filled with cuts of boned-out beef, each of which is wrapped in greaseproof paper. This allows of individual cuts being taken from frozen storage as required.

(iv) *Interstate Transport of Chilled and Frozen Beef.*—With the increase of transport difficulties due to Defence needs, further problems have arisen in the intrastate and interstate transport of chilled and frozen beef. Conferences have been held with officers of the Railway Departments concerned and steps have been taken to overcome some of the major difficulties. A discussion on the subject was published in the December issue of *Food Preservation Quarterly.*

(v) *Dehydrated Beef.*—The main investigational work of the laboratory has been in connexion with dehydrated beef. An article on the subject was contributed to *Queensland Country Life* for its annual beef supplement. The investigations have yielded results leading to a closer definition of ideal processing conditions and, it is hoped, they may lead to a reduction of processing costs. Particular attention has been given to the improvement of flavour. This has been brought about by (*a*) reducing the temperatures to which the material is subjected during processing to the lowest point practicable; and (*b*) returning the extractives which come out of the meat in the initial cooking. Making the latter economically practicable appeared to be a difficult problem, but it seems that it will be feasible to return the extractives without previous concentration.

In work on storage, the most valuable observation was that dried meat is very subject to infestation by a beetle, *Dermestes vulpinus*, the most obvious evidence of which is its very active larval form. In the absence of a normal environment such as soil, the larvae chose laboratory corks for pupation. Both beetle and its larval form were completely destroyed by heat treatment at 140° F. for 30 minutes. Experience certainly indicates the desirability of prompt packaging of meat after dehydration so that this beetle, which is quite common in most meat works, being seen especially in horns, will have no opportunity to deposit its eggs in the material.

The field has been surveyed for beginning work on the dehydration of pork.

(vi) *Moisture Content in Meat Extract.* — Investigations into the rapid method for the determination of moisture in meat extracts referred to in the last annual report were interrupted during the year, when the works with which the laboratory was co-operating temporarily discontinued the manufacture of the extracts. However, work on the method has now been resumed, and should be completed in the near future.

(vii) *Canning.*—A number of calls have been made on this laboratory for assistance, particularly in connexion with (*a*) problems of spoilage of meat caused by microbial proliferation due to either inadequate chilling and storage before the meat had reached the boning room, or subsequent to boning-out but before canning; (*b*) vacuum lines, especially in relation to vacuum closing of 6-pound taper cans; and (*c*) removal of occluded air from cans of cold-cured mutton. The investigations under (*a*) revealed some serious deficiencies in chilling facilities and indicated that, in some canneries in the summer months, the microbial margin of safety was so small that only a very short period of further holding of meat before canning would lead to spoilage.

3. Canning Investigations.

(i) *General.*—The Canning Section has continued to give a considerable amount of direct assistance to the Controller of Defence Foodstuffs and to the Department of Commerce and Agriculture in connexion with current production programmes for canned foods and canned and bottled fruit juices. Close liaison has been maintained with food technologists in the U.S. Army.

Pending the development of the Food Technology Section in the defence foodstuffs organisation, the Canning Section undertook the regular examination

of samples of canned foods packed in N.S.W. and of fruit juices from all producing States. These samples were examined for quality, bacteriological condition, and efficiency of can sealing, with a view to determining their acceptability for Service use. During the year, approximately 500 samples of canned foods and 200 fruit juices have been reported on. This examination work has given the Section a very useful and comprehensive picture of the canning industry, and many canners have been directly assisted in improving their production methods.

The Section was responsible for drawing up a series of specifications for canned vegetables, based on American Standards, which were adopted as Australian Food Council Specifications. Educational activities have been continued in the form of brief courses of lectures and practical demonstrations in canning technology and the inspection of canned foods. Two groups of Department of Commerce and Agriculture officers, two groups of Department of Supply and Shipping officers, and one group of Army Supply officers received instruction at the laboratory and in commercial plants.

The research activities of the Section have been greatly assisted by the installation of new equipment, including a steam blancher, an internal pressure can-testing machine, and a powered grinding wheel table for cutting sections of can seams.

(ii) *Vegetable Canning.*—The section has given a considerable amount of time to the solution of day-to-day problems encountered by vegetable canners in the course of recent accelerated production programmes. Serious spoilage has occurred in some vegetable packs, chiefly because of the use of bacteriologically inadequate processes. The position has now been remedied by the adoption of processes recommended by the National Canners' Association of America, for all vegetables packed for Defence contracts. The N.C.A. spinach process has been applied to silver beet, but such application has been questioned. A programme of heat penetration studies on silver beet packs has therefore been undertaken, in an endeavour to establish suitable processes.

In co-operation with the N.S.W. Department of Agriculture, canning trials were conducted on 12 varieties of field beans from the New England district and 15 varieties of tomatoes from the Bathurst Experiment Farm.

A survey was made of the vitamin C content of tomato varieties grown in the Bathurst district and of the vitamin C content during the processing of canned tomatoes, tomato juice, and tomato puree. The results indicate extreme variability in the vitamin C contents within varieties. The vitamin C retention during processing is high, and canners should have no difficulty in complying with the content of 17.5 mg. per 100 ml. required by Australian Food Council specifications for tomato products.

(iii) *Meat Canning.*—In this field also, many canners have been assisted with production problems. One problem encountered by several canners, is that of low vacuum, and the appearance of "springy" cans in various packs of canned meats. A generally satisfactory solution to this problem has not yet been reached, but several interesting lines of attack have been opened up. Another widespread problem, that of black-staining in corned mutton and corned beef, continues to crop up apparently haphazardly. Opportunity has been taken at several outbreaks to collect information on the probable causes of the black-staining phenomenon.

(iv) *Container Investigations.*—The Section has been greatly concerned by the high proportion of leaky cans which is present in canned food consignments and by the number of cases of spoilage in canned foods which are directly attributed to faulty can manufacture or can sealing. The laboratory has developed convenient techniques and equipment for the rapid testing of cans, and many canners and can-makers have been assisted to improve the efficiency of their can-sealing. An attempt has been made to obtain fundamental data in this field, and the effect of variations in tinplate thickness on closing machine adjustments was studied. It has been encouraging to note in recent months a significant decrease in the proportion of leaky cans in samples submitted for examination.

Large sized tinplate and blackplate containers have also been tested for suitability for gas-packing dry foodstuffs. The "Parkerising" phosphate coating has been applied as a surface treatment for blackplate drums for dry foodstuffs. Assistance was given to the Dairy Research Section in arranging two experimental shipments of dehydrated butter fat in plain and lacquered blackplate drums.

Investigations on internal lacquers for food cans have continued, chiefly performance tests on commercial formulations. Essential raw materials for many lacquers of well established reputation are now in short supply and substitutes are being sought. The external coating of cans to prevent rusting was studied, and 10 commercial external lacquers were tested for protective qualities. In general, petroleum-distillate-soluble finishes were superior in performance to alcohol-soluble types. The use of wool-fat and tallow as rust preventatives on cans was also investigated. Wool-fat in particular gave very efficient protection, but there are certain practical difficulties associated with its use.

4. Dehydrated Foodstuffs.

(i) *Dried Egg.*—Experiments to determine the storage life of different samples of dried egg under various conditions have been continued. The results confirmed those obtained previously, namely, that deterioration of flavour and dispersibility was rapid at temperatures of 85°F. or higher, and that samples of initially good quality had a longer storage life than poorer samples. Some samples which had been stored for twelve months at approximately 18°F. were transferred to higher temperatures, and it was found that the rate of deterioration was approximately the same as that of the fresh samples. The examination of samples from commercial plants showed that the general quality of the output was superior to that of the 1941-42 season. Some time has been spent on the comparison of analytical methods used here and in overseas laboratories.

(ii) *Dried Meat.*—The storage experiments on dried mutton commenced during the previous year were completed. The chemical determinations carried out on the fat extracted from the meat proved to be of no value in determining changes during storage, and it was necessary to rely on the results of standardized tasting tests. When air was excluded by packing the meat in sealed containers in an inert gas or in the form of a compressed block, storage for as long as twelve months at 98°F. appeared to cause little deterioration in quality. Investigations aiming at obtaining a satisfactory compressed product have been commenced. Various methods of determining the moisture content of dried meat have been compared.

(iii) *Dried Vegetables.*—Five schools have been held in the course of the year at the request of various departments. Lectures and demonstrations covering the various phases of processing and testing were arranged, and samples were prepared to illustrate the effects of both good and bad practice. A set of detailed notes on the dehydration of

vegetables was prepared with the assistance of officers of the Department of Commerce and of the U.S. Army and has been widely circulated.

During the year small scale work in the laboratory has covered the dehydration of potato, cabbage, carrot, turnip, parsnip, beetroot, celery, pumpkin, and parsley. In the case of potatoes the variables studied have been methods of peeling, type of subdivision, blanching time, blanching method (water or steam), the use of sodium sulphite in conjunction with peeling and blanching, and temperature and humidity conditions during drying. The effect on the retention of ascorbic acid was studied as well as the general quality of the product. Similar work was carried out on cabbage in addition to study of the retention of ascorbic acid at various stages during drying at different temperatures. This latter study was extended to swede turnip. In the case of other vegetables the only variables were blanching time and drying temperature.

The effect of variety, district, and soil type on the quality of Tasmanian potatoes for dehydration is being studied, the material being collected by officers of the Tasmanian Department of Agriculture. The effect of the concentration of reducing sugar on the quality of the dehydrated product is being followed, and changes in reducing sugar content of the fresh potato during storage are being determined. A limited amount of work is also being done with potato varieties from other sources. Eight varieties of onions were compared at the request of the N.S.W. Department of Agriculture. These varietal studies will be extended shortly to carrots and cabbages in collaboration with the Commonwealth Research Station, Merbein.

Some work was done in the older dehydration plants early in the year in which the chief study was of the change in vitamin content of the vegetable during processing. Recently, various types of work have been done in a new plant.

Storage experiments have been carried out with various vegetables, but it has not been possible yet to follow up in detail the many variables involved. Dehydrated vegetables prepared under proper conditions appear to keep well at temperatures of 70°F. or lower, but further work needs to be done to improve the life at temperatures in the vicinity of 100°F. The storage life is considerably prolonged by drying to low moisture contents. The use of sodium sulphite in conjunction with blanching has been found to be beneficial, particularly in the case of cabbage.

Methods of analysis which have been intensively studied are the determination of moisture, carotene, and thiamin.

(iv) *Special Rations.*—At the request of the Army a considerable amount of work has been done on special rations.

5. Microbiological Investigations.

(i) *General.*—The work of this Section has been devoted almost entirely to canned foods and to egg investigations.

During the year the examination of canned foods has become the major activity at the Sydney laboratory, the number of samples examined being more than twenty times that submitted in the previous year. The volume of this work has often been a strain on the resources of the laboratories, and consequently the comprehensive investigation of some problems has been delayed or suspended. It is expected, however, that this position will soon be relieved when some of the examinations are taken over by other laboratories.

Investigations on shell eggs have been continued as part of the five-year programme carried out in co-operation with the Egg Producers' Council. This programme was completed during the year and, the major causes of wastage having been defined, further experiments on shell eggs are not proposed at present. The investigations on the bacteriology of egg pulp will be continued.

Tests of measures for the control of mould wastage in apples were continued from last year, but no further trials during the war are contemplated.

(ii) *Egg Investigations.*—(*a*) *Cleaning and Storage Experiments at Sydney and Melbourne.*—The results reported last year were confirmed in a further series of experiments in three States. This year attempts were made to discover the mechanism by which infection is introduced into the eggs, and to devise suitable measures to control wastage resulting from machine cleaning. It has now been established that the cleaning machines, and not the soiled eggs themselves, are the important source of the bacteria which cause the wastage. During machine cleaning these bacteria penetrate to situations where they are protected substantially, as disinfectant dips after machine cleaning failed to reduce wastage significantly. Suitable disinfectant solutions used during the cleaning operations have resulted in the reduction of wastage caused by cleaning machines. However, the minimum concentrations which, when applied regularly, will be required to control wastage effectively, are not yet known precisely. The keeping quality of unwashed clean or soiled eggs was again shown to be excellent. It is proposed to prepare the results of the five-year programme for publication.

(*b*) *Egg Pulp Bacteriology* (*at Melbourne*).—The major portion of these investigations has been connected with the development of a simple rapid test for the evaluation of egg pulp quality. The reductase test, using resazurin as an indicator, has given promising results and the results of some experiments with commercial samples of Victorian egg pulp have been published. Tests have shown that the type of organism present in the egg pulp has a considerable influence on the rate of reduction of the dyestuff, and work is now in progress to determine the part played by various bacterial types in the reductase tests on commercial pulp samples. The reductase test is applicable to samples of frozen pulp when materials such as gelatine are used to stabilize the homogeneity of the emulsion.

(iii) *Canning Bacteriology.*—The greater part of the resources of the laboratory are given over to the bacteriological examination of caned foods. In all, some 3000 individual cans or bottles have been tested during the year. Approximately half of this material was submitted by the Controller of Defence Foodstuffs for reports on the bacteriological conditions of the product. Routine examinations are made after standard incubation tests for spoilage organisms. These examinations will shortly be taken over by the Department of Commerce and Agriculture. The remaining half of the material included spoiled or suspected material submitted by private organizations or government departments and some experimental material canned in the Division's laboratories. With these examinations the significant results are usually determined within a few days, but occasionally more extended investigations are required before the cause of faults can be established and corrective measures indicated.

Research projects are being prosecuted as far as the above commitments will allow. A considerable array of sporing organisms isolated from spoiled canned foods await further study, and estimates of

the thermal death times of their spores. To expedite this work the full-time services of one member of the staff have now been directed to thermal death time studies.

Instruction in canning bacteriology has been given to several groups from various government departments and to bacteriologists from other organisations.

During the year some exploratory work on factory contamination was carried out in canneries. An assessment of the level of spoilage existing in some stocks of canned vegetables was made for the Controller of Defence Foodstuffs.

(iv) *Miscellaneous.* — Various fungicides and disinfectants were tested for the control of mould wastage in apples dipped in wax emulsions. Of nine materials used none showed results of any promise. Some bacteriological estimations on dried eggs and meat showed the viable organisms to decrease steadily at a rate depending on the temperature of storage. An outbreak of food poisoning due to cooked ham and involving a large number of people was referred to the laboratory. The outbreak was due to the ingestion of an enterotoxin which had been elaborated by Staphylococci.

6. Fruit Storage Investigations.

(i) *Skin Coatings on Apples.*—For the past three seasons extensive experiments on the use of skin coatings for prolonging the storage life of apples have been carried out in conjunction with the New South Wales Department of Agriculture. As a result of these investigations, large scale trials were carried out in 1942 in the main apple-growing districts of New South Wales where fairly large quantities of Jonathan, Delicious, Granny Smith, and Democrat apples were hand-dipped in an alcoholic solution of 8 per cent. castor oil and 2 per cent. dewaxed shellac. Smaller quantities of these varieties were also treated with oil and wax emulsions of 10 per cent. concentration. The cost of treatment for materials and labour was about fourpence per case.

The best results were obtained with the solution of castor oil and shellac, and under favourable conditions the use of this preparation increased the life of the various varieties in common or unrefrigerated storage by 50 per cent. In some cases lenticel spotting developed, and when the fruit was immature and atmospheric temperatures were relatively high at the time of treatment alcoholic flavours and internal browning developed, but these injurious effects were not produced by treatment with emulsions. Therefore, under conditions where the castor oil and shellac is likely to be injurious, the emulsions are preferred. However, the emulsions were less effective than the solution of castor oil and shellac in retarding yellowing, and wax emulsions caused calyx injuries and subsequent rotting. Wax emulsions were the most effective in controlling wilting and are particularly valuable for Jonathans, which lose water very rapidly in the packing shed.

The most striking effect of treatment was the marked retardation of yellowing, and treated Granny Smith apples remained green in colour for five months in the packing shed. The treated fruit was less wilted, firmer and crisper, and more juicy than untreated fruit, and the flavour and acid were retained longer by treatment. The incidence of Jonathan Spot, lenticel and late scald, breakdown, and bitter pit was greatly reduced by treatment.

The effect of the skin coatings is largely dependent on the maturity of the fruit at the time of picking, as immature fruit may develop alcoholic flavours whereas over-mature fruit may develop skin disorders and is more susceptible to mould and calyx rotting. During 1943 attention has been concentrated on the effect of maturity, and various pickings of the four varieties have been made at Orange and treated with the solution of castor oil and shellac and with different oil and wax emulsions. In 1942 very satisfactory results were obtained in Tasmania and South Australia, especially with the later varieties, and further investigations are being conducted in these States and also in Victoria.

The investigations in the laboratory have been concerned with the effect of maturity, temperature of storage, and concentration of the skin coating on the storage life of apples. The storage life of the main varieties over a range of temperatures has been considerably increased by skin coatings, and the results obtained with Jonathan apples in cool storage have been at least equal to those obtained previously by gas storage. The cool storage life of Granny Smith and Delicious apples has been prolonged and the development of superficial scald has been controlled by treatment with an emulsion of peanut oil. A considerable amount of time has been spent in preparing and testing oil and wax emulsions. It is now evident that the relative amount and nature of the emulsifying agent is of greater importance than the type of wax or oil used. Emulsions prepared with ammonium soaps are more satisfactory than those prepared with sodium or potassium soaps, as they give more water-resistant films and are less likely to injure the calyx of the fruit.

Emulsions of mineral or vegetable oils can be easily prepared with ammonium oleate, but they give the fruit an unnaturally dull appearance which cannot be improved by incorporating other protective substances in the emulsions. A more highly dispersed emulsion can be prepared by emulsifying three parts of White Oil D and one part of lac wax with ammonium oleate and a very bright and attractive film can be obtained by mixing with the emulsion shellac or a mixture of shellac and casein in a 3 per cent. solution of ammonia. This emulsion can be used for hand-dipping the fruit and has given good results in recent trials. The proportion of shellac to oil can be varied to suit any particular variety.

Wax emulsions are more effective than oil emulsions in retarding moisture loss, but they require higher concentrations and more alkaline soaps for their preparation, and sodium soaps have usually been used. An emulsion of a mixture of paraffin wax, beeswax, and lacwax has recently been prepared with ammonium oleate and appears to be satisfactory for apples.

Certain experiments on the effect of temperature on the respiration rate and composition of the internal atmosphere of the various varieties of apples treated with different skin coatings have been carried out in conjunction with an officer of the Botany Department of the University of Sydney.

(ii) *Vegetables.* — Loss of moisture in carrots, turnips, cucumbers, and tomatoes has been considerably reduced and the yellowing of cucumbers has been retarded by treatment with skin coatings. Wax emulsions were more effective than oil emulsions or solutions in retarding wilting.

(iii) *Dried Fruits.*—An increasing proportion of the Australian apple crop is now being dehydrated; sulphuring is essential to prevent browning during drying and subsequent storage. Direct sulphuring has been the commonest method, but the short exposure of whole fruit to sulphur fumes and slow drying methods have resulted in a low residual content of sulphur dioxide in the apple slices. In 1942 the sulphuring of slices by immersion in various sulphite solutions was investigated, and the effect of the concentration of the solution, time of immersion, and subsequent drying conditions on the sulphur dioxide content of the dried material was determined.

Solutions of sodium and potassium metabisulphite in water were used, but as these substances are not manufactured in Australia the use of sodium bisulphite and sodium sulphite as possible substitutes was also considered. It was found that a sulphur dioxide content of ten grains per pound of dried fruit could be obtained by dipping the slices for six minutes in a 1.5 per cent. solution of sodium or potassium metabisulphite, sodium bisulphite, or sodium sulphite acidified to a pH value of 3 to 4. The retention of sulphur dioxide during drying was dependent on the drying conditions during the initial stages; the more rapidly the fruit was dried the higher was the amount of sulphur dioxide retained.

In 1943, methods for increasing the sulphur dioxide content of fruit which has been insufficiently sulphured are being investigated.

Storage tests with dried apple are in progress covering the following variables: (*a*) sulphur dioxide content, (*b*) water content, (*c*) temperature of storage, and (*d*) time of storage. Preliminary experiments on various methods of sulphuring clingstone peaches were also carried out.

7. Fruit Products Investigations.

(i) *Fruit Juices.*—Officers of the Section were largely responsible for the organization of the large scale production in several States of canned and bottled citrus juices for antiscorbutic purposes in Service rations. The production of canned apple juice, fortified with synthetic vitamin C, was also commenced in N.S.W. and Tasmania. Army demands thus brought into being in a few months an industry which the Division has endeavoured to stimulate for some years. The majority of fruit juice processors installed the type of equipment for de-aerating and pasteurizing juices which was developed and used successfully by the Division. A considerable amount of technical assistance has been given to processors in setting up plant. The greater proportion of the citrus juice pack was bottled, but lacquered cans were successfully used by several packers. These cans were lacquered internally with a finish which had proved superior to others tested in laboratory packs over a long period.

Citrus juices, including orange, lemon, and grapefruit juices and blended orange and grapefruit juice, were received from all producers for examination and samples were retained in storage at atmospheric temperatures and at 100° F. Examinations after storage showed that vitamin C was well retained during 6 months at ordinary temperatures; at 100° F. approximately 20 per cent. loss occurred. In all juices there was a significant decline in palatability after 6 months in ordinary storage, and after 3 months at 100° F.

In the fortification of apple juice, it was found that vitamin C added prior to pasteurization was rapidly destroyed by enzymic action. A technique of fortification by adding vitamin C tablets to individual cans just prior to filling was devised and has been successfully applied commercially. The apple juice certification scheme in co-operation with the Apple and Pear Board has been carried on, and 31 samples of apple juice and ciders were examined during the year.

A preliminary study was made of the fortification of artificial citrus cordials with vitamin C; the retention of the latter is very good in the syrup, and reasonably good in the diluted beverage.

Concentrated orange juices of various solids contents have been prepared. Highly viscous concentrates with approximately 70 per cent. solids will keep without preservatives. Reasonably fluid concentrates with approximately 50 per cent. solids are satisfactorily preserved by 4 grains per pint of sulphur dioxide. There is evidence that concentration of navel orange juice to approximately half its volume largely eliminates the bitterness usually associated with processed navel juice. A concentrated juice of this type is being canned by one processor this season.

(ii) *Solid Jams.* — The preparation of "solid jams" was investigated. These products are intended to be marketed in bulk and retailed in wrapped blocks, thus conserving tinplate. Solid plum jams and solid raspberry jams of adequate strength were prepared; less success was obtained with apricot jam. Blocks of adequate strength, wrapped in moisture proofed regenerated cellulose films or waxed paper, kept reasonably well for three months under conditions typical of southern Australia, but deteriorated rapidly under tropical conditions. In the course of these investigations the extraction of apple pectin was studied, and a number of apple varieties and apple by-products were examined as sources of pectin.

(iii) *Marmalade.* — The shortage of citric acid prompted studies on the use of other acids in marmalade. It was found that lactic and phosphoric acid were suitable substitutes for citric acid from the points of view of sugar inversion, set, and palatability. Sulphuric acid was not satisfactory.

8. Physical Investigations.

(i) *General.* — As in previous years, a large proportion of the time of the Physics Section has been devoted to the maintenance and running of mechanical equipment, the design and construction of apparatus, the statistical analysis of experimental results, and the design of experiments, and to collaboration with other Sections on various problems. Officers of the Section have assisted in the conduct of the schools referred to elsewhere in this report.

(ii) *Substitute Containers.*—This work has been carried out in co-operation with the Division of Industrial Chemistry and under the auspices of the Tinplate Substitute Container Committee of the Tinplate Board. This Division has been responsible for measurements of porosity and permeability to water vapour of a large number of existing types of substitute container and also of a few types produced in America and various experimental types made by Australian manufacturers. Estimates of the maximum permissible permeabilities for various storage periods and conditions for several representative foodstuffs have been worked out and used to interpret the permeability data on existing containers. A study of a number of surface coatings designed to render containers grease and oil proof has been undertaken, and some promising results have been obtained. A summary of most of the results obtained in these substitute container investigations has been incorporated in the first number of the Bulletin issued by the Tinplate Substitute Container Committee.

(iii) *Water Relations of Foodstuffs.*—Some measurements of the water relations of a number of foodstuffs have been carried out to supply information required by other Sections of the laboratory or for container investigations. Among the materials studied were jams, honey, malt extract, golden syrup, treacle, and some proprietary products and special rations.

(iv) *Smoke Curing of Fish.*—Some further work has been carried out with mullet and Australian salmon. It was found that with mullet, temperatures and vapour pressures much higher than those commonly used overseas could safely be used, whereas the upper limits for Australian salmon are probably

not very different from those for the species commonly smoke-cured in Scotland and Canada. A summary of the results obtained has been published in the Council's *Journal*.

(v) *Canning.*—Further heat penetration studies have been carried out in a number of packs, including cabbage, tomato, silver beet, and some meat packs. At the request of the Department of Supply and Shipping and the cannery management, a survey of temperature conditions in the retorts at one cannery was carried out. Some other tests of commercial equipment have been carried out in response to requests from the managements of the canneries concerned.

(vi) *Dehydrators for Foodstuffs.*—The investigations of physical problems associated with the production of dried foodstuffs have been continued. A spray drier to evaporate 5 lb. of water per hour was designed and has been constructed by an outside firm. Preliminary tests on this drier have been carried out. A second small cabinet drier of modified design has been constructed in the laboratory and is now in use for vegetable dehydration investigations. A larger cabinet drier is being constructed for the laboratory by a Sydney firm.

Problems associated with bin drying as a finishing stage for dehydrated veegtables have been considered. Silica gel dehumidifiers may be very suitable for this purpose, and several samples of this gel have been tested to determine their efficiency in dehumidifying air.

A survey of temperature, humidity, and air flow in a commercial vegetable dehydrator was carried out. Modifications of the dehydrator were suggested and should lead to improvement in the quality of the product and increased output.

(vii) *Electrical Moisture Meters.*—A rapid and reasonably accurate method for determining the water content of dehydrated foodstuffs is urgently needed for factory control of the processes. Electrical moisture meters have supplied a similar need in some other industries, but the moisture content of most of the dehydrated foods is below the range of the meters commonly used elsewhere. A number of electrical meters primarily designed for other materials have been tested for dried vegetables and several have been found unsuitable. A meter designed and built by an Australian firm for the testing of dehydrated foods was calibrated for four dehydrated vegetables (cabbage, carrot, onion, and potato) and the effects of variations of temperature and fineness of grinding were studied. The performance of this machine seems very promising and it has now been taken over by the Department of Commerce and Agriculture for further testing. Considerable development work on a capacitance type meter was carried out and specifications for an instrument were discussed with an Australian manufacturer. It is hoped that a meter constructed to these specifications will soon be available for testing.

IX. FISHERIES INVESTIGATIONS.

1. General.

During the year 1942-43, conditions became such that it was inadvisable to continue the research operations of M.V. *Warreen,* which was accordingly loaned for service elsewhere after rather more than four years' work for the Council. It may be said that the first phase of the investigations of the Division of Fisheries ended with the transfer of the vessel. Certain preliminary conclusions have been reached, and will be made the subject of a special article in the Council's *Journal.* It was not possible to conduct absolutely conclusive tests of live-bait or purse-seine tuna fishing, but these will be arranged as soon as circumstances permit. However, it can be stated that the live-bait method of fishing (for striped tuna especially) holds out considerable promise of being successful. During the past year, tests of pelagic fishing methods have been confined almost entirely to the use of specially constructed purse-seine nets on Tasmanian fishes, *e.g.,* sprat and mackerel. The seasonal run of sprats was unfortunately very poor—for the first time in four years—but mackerel were plentiful and were successfully seined.

In view of the great importance of the edible shark (vitamin-oil producing) industry, the intensive survey of the occurrence of sharks was continued; it resulted in the finding of payable amounts in southern Tasmanian waters. The object of this work is to stabilize and, if possible, to increase the supply of shark oils.

Progress was made during the year in the commercial production of agar-agar from seaweed, and new sources of the weed were discovered. This work is of importance in view of the cessation of agar supplies from Japan. Cognate work on the production of other seaweed products, especially useful in war-time, was commenced.

Generally speaking, the more fundamental biological and hydrological studies were reduced to a level sufficient merely to sustain the necessary continuity. These studies aim at establishing a basis for understanding and predicting fluctuations in fish stocks, for conserving the latter in a rational manner, and for estimating the extent of possible new fisheries.

During the year, the Division carried out a comprehensive survey of the fishing industry for the manpower authorities, the aim being to suggest means whereby the maximum output could be obtained with the personnel and gear available. One officer was seconded to the allied forces to inaugurate fishing activities in front-line areas in the tropics. Information was also contributed on the possibility of establishing a national whaling industry, and operations will begin in the coming year. This industry is of importance in view of the need for tanning oils during war-time.

2. Technological Industry.

(i) *Agar-agar.* — The technical work connected with the commercial production of agar was, during the past year, carried on in conjunction with various firms interested in production. A scheme for small-scale commercial production was worked out and will probably be put into operation in Western Australia, to meet present local needs. Large-scale production has begun in Sydney, and the firm concerned aims at producing, in the near future, at the rate of 100 tons of agar a year. The agar so far produced commercially has been of good quality, though it has a higher viscosity and setting point than the Japanese agar. Studies made at Sydney University show that, with limitations imposed by these properties, the Australian material is suitable for most bacteriological purposes. These tests were made on crude commercial agar, and not on the specially prepared bacteriological product.

The Division is at present engaged on an intensive survey of seaweeds suitable for agar manufacture, and in a detailed survey of known *Gracilaria* beds at Botany Bay and at Middle Harbour, Port Jackson. Seasonal variations in quality of agar are also being studied, but the investigation is in its early stages. At the present time there appear to be about 300 acres yielding *Gracilaria* in Middle Harbour. *Hypnaea,* too, is a widespread genus which yields an agar with apparently a lower viscosity. This work is possible as the result of a grant made to the Division by the Department of War Organization of Industry.

(ii) *Edible Shark Pack.*—For economic reasons it is necessary to utilize the flesh of sharks primarily captured for their liver oil which is rich in vitamin A. There is a tendency for this flesh to develop an ammonia taint if kept even a short time. Further work has been done in connexion with this problem, and some successful experiments were made in canning edible shark. The fish was canned while suitably fresh, using various protective dips and also plain brine; all samples have opened up well after storage of up to 2 months. The flavour of canned shark is quite agreeable, and the appearance of the packs is good. This is the third occasion on which successful packs have been made, but on another occasion a tomato sauce pack gave a strong ammonia taint. Thus it appears that shark can be successfully canned, but the conditions required for success are not yet completely clear.

Bacteriological tests suggest that *Micrococcus* spp. predominate in shark flesh at all stages of decomposition, and there does not seem to be a bacterial succession as was recorded from teleost fish. Many of these micro-organisms produce ammonia from shark flesh. It is not yet clear to what extent spoilage of shark flesh is due to bacterial activity, on the one hand, and to the action of flesh enzyme on the other. The possibility of two sources of ammonia production from the urea in the flesh makes the problem a complex one, and it is receiving further study.

(iii) *Sodium Alginate, Potash, and Iodine.*—The advice of this Division has been asked regarding these products, and a pilot plant is working in Sydney with a view to their large-scale production. Sources of supply of suitable seaweeds are being examined, and the prospects in this respect appear favourable.

(iv) *Fish Oils.*—Throughout the past year, livers from no fewer than 20 species of shark and ray were examined for oil and vitamin content in an effort to find livers rich in vitamin A and possibly vitamin D to augment the supplies of snapper shark livers being used in Victoria. Most of the livers examined were obtained from the N.S.W. coast. Some species of whaler shark were found to possess livers rich in vitamin A, but insufficiency of supplies of these livers prevented commercial utilization. The snapper shark on the N.S.W. coast was found to contain a liver as rich in vitamin A as the same species from the Victorian coast, but attempts to organize large-scale fishing experiments for this species off Eden failed owing to the shortage of suitable fishing craft. As soon as conditions permit, these experiments will be carried out.

The plant designed under the direction of the Division continued to utilize the Sydney fish market offal, recovering 2 gals. oil per drum of offal. The offal residue is being dried for fertilizer. This project is saving the Sydney Council considerable expense (4s. per drum for removal) as well as solving the problem of disposal of a difficult waste material.

3. Fishing Industries.

(i) *Tuna Investigations.*—The withdrawal of the investigation vessel, *Warreen,* from service with the Division during the year broke the continuity of tuna observations on the south-east coast. The previous periodical reconnaissances had enabled a record to be maintained of the variation in abundance of the various species over a number of years. In the case of southern bluefin (*Thunnus maccoyii*), the use of the standard catching gear (by trolling whilst the vessel was under way) enabled the compilation of index numbers for the successive seasons. Through these index numbers tuna fluctuations could be compared with the results of plankton and hydrographical investigations, as well as with observations on other marine phenomena. This work has been entirely suspended. Some indications of the character of the 1942-43 season were, however, obtained from observer-correspondents along the coast. A restricted amount of tuna-trolling was carried on in southern N.S.W., and the result of such fishing attempts indicated that the season was a very poor one, probably the poorest since the Division began its investigations in 1938. Reports from Tasmania referred to a similar lack of southern bluefin. As in the previous year, co-operation with a group of South Australian anglers enabled the tuna stocks to be sampled in certain areas in that State. This showed, among other results, that southern bluefin were notably scarce there as well.

As a contrast, comparatively large catches—having regard to the experimental nature of the fishery—were made of the sub-tropical northern tuna (*Kishinoella tonggol*) on the south coast of N.S.W. These tuna were caught by beach hauling-nets incidentally to other fishing operations, and the results obtained suggest that a tuna fishery could be carried on by this inexpensive method. The beach purse-seine constructed for salmon fishing might with advantage be used for the northern tuna also. All the tuna caught this season have been canned, and through the co-operation of the canneries full biological data were obtained. Arrangements are being made for skeleton surveys of the N.S.W. area during the forthcoming season, to sample the tuna populations in a similar manner to that adopted in South Australia.

Before he retired from the staff, on the withdrawal from service of the *Warreen,* Captain A Flett prepared full reports of the vessel's fishing experiments on tuna and other fishes. These will be published in due course.

Sea-bird Fluctuations.—During October, November, and December, 1942, exceptionally heavy mortality of short-tailed mutton-birds (*Puffinus tenuirostris*) occurred along the east Australian coast, from at least as far south as Twofold Bay to Fraser Island, Queensland. This phenomenon, which is an annual one, but one varying greatly in intensity from year to year, appears to correlate with the relative abundance of southern bluefin tuna. The possibilities of using dead mutton bird statistics as an index of changing conditions in the Tasman Sea, including plankton and hydrology, are being investigated.

(ii) *Shark Investigations.*—The survey of shark-distribution in south-eastern Australian waters was continued. Data on the breeding habits and food of sharks were collected incidentally. Although the school shark has been found to be most suitable for vitamin-oil production, several species are valuable for food. Several experimental long-lining cruises were made in the *Aralla* from Hobart, and the existence of a payable shark fishery was demonstrated. Sharks and rays were tagged for the first time in Australia; so far, only one tag has been recovered.

Through the courtesy of the Department of Works and Local Government, Sydney, access was given to the large amount of information on shark meshing filed there. This yielded valuable statistics on the seasonal occurrence of sharks off the metropolitan beaches. Several trips from Sydney were made on shark-meshing vessels. Black-tip sharks, previously believed to be tropical stragglers, were found to be young whalers, a local species.

Since September, 1942, regular weekly samples of trawled sharks have been studied and livers set aside for oil-analysis. By arrangement with the Australian Museum, a volunteer assistant, Miss E. Pope, has rendered valuable aid in this work.

Field observations on sharks, tunas, atherines, and other fishes, and on fishing methods, were made in

South Queensland. The sharks were all tropical forms, mostly belonging to new or little-known species. These have since been classified, descriptions and figures having been prepared for publication. Such species are not in general of the type yielding liver oils of high vitamin value, and their use commercially would be incidental to fishing activities carried out on other species.

(iii) *Clupeoid Fish Investigations.*—Investigation on clupeoids (*i.e.,* herring- and sardine-type fishes) carried out during the past year have related almost entirely to Tasmanian waters.

(*a*) *Sprat* (*Clupea bassensis*).—As briefly indicated in the last annual report, a programme of investigations was begun early in 1942 to follow up and if possible substantiate the tentative conclusion, drawn previously from the experience of the *Warreen*, that sprats and "mackerel" (*i.e.,* horse-mackerel, *Trachurus novae-zelandiae*) in south-eastern Tasmanian waters could be captured with some form of small purse-seine net, worked from small boats, during the shoaling season between late summer and early winter. This work has now, after considerable initial difficulties, achieved a significant measure of success. A purse-seine net has actually been successfully operated for the first time in Australian waters, with the capture of four tons of mackerel by a crew of three in waters near Hobart. This performance has since been repeated in substance by the same crew.

This programme of work was initially undertaken in conjunction with the Tasmanian Fisheries Division, which arranged to supply vessel and personnel, while this Division provided the nets and the service of a member of the research staff. Unfortunately, the only vessel available at the time, the converted motor-yacht *Arcadiar*, was of a quite unsuitable type, and on this account, as reported previously, no success with the method was attained during the 1942 season. Much useful experience was gained, however, concerning the adaptation of small craft to this type of fishing; in particular it was found that much of the expensive heavy gear previously thought essential for handling a purse-seine (turntable, boom, &c.) was not absolutely necessary for nets of the dimensions, *i.e.*, about 120 fathoms long, used in these tests.

The Tasmanian Government had agreed, at the time the work began, to construct a special 65-ft. fishing vessel to operate both purse-seine and Danish-seine nets in local waters but, as this vessel is still under construction, no progress could have been made during the 1943 fishing season had not private enterprise intervened. Representatives of two independent concerns, at their own requests, were lent nets. These interests set aside two vessels for the work, the *Mary* (56-ft. ketch type) and the *Jester* (59-ft. Danish-seine type), neither of which was the most suitable craft for the purpose, although it was possible, on the basis of experience with the *Arcadiar*, to rig them out fairly satisfactorily. The Division's officer also collaborated with the enterprise by demonstrating the method of fishing to the crews and by accompanying them on numerous cruises in search of fish during the 1943 season.

Unfortunately the 1943 season turned out to be one of extreme scarcity of sprats, which are recognized to be comparatively easy to capture, owing to their relative quietness when schooling; the mackerel is wilder and harder to encircle, especially with such short nets. These vessels concentrated at the outset on the areas in which, in previous years, sprats had been numerous at this time, but for the reasons just given this resulted in considerable loss of time and money; the *Jester* dropped out of the venture after a while, but the *Mary* transferred her attentions to mackerel and persisted, with very satisfactory results. These successes are naturally gratifying to the Division in view of the long series of failures it has encountered in attempting successfully to adapt the purse-seining technique to Australian conditions. It appears likely that private enterprise will proceed further with the venture next year, and the Tasmanian Government (whose vessel should then be ready) will certainly do so; it should thus yet be possible for this new technique to make a significant contribution to war-time food production. The Division will of course continue to assist all these operations.

It is not suggested that purse-seining or allied methods of fishing will ever achieve, even in Tasmania, the degree of importance they have attained elsewhere, but it seems certain that a few vessels could operate profitably in the season, and between them make a moderate contribution to Australian production of canning (and curing) fish. It is clear, of course, that years of scarcity will occur, as they do in practically all fisheries, but it is possible that biological study may enable such years to be foretold. Preliminary observations suggest that the present scarcity of sprats will not persist next season, and if this be so it is reasonable to expect that purse-seining will then do fairly well in these waters.

(*b*) *Anchovy* (*Engraulis australis*). — Further observations on the anchovy in Tasmania tend to strengthen the opinion expressed in the previous report, and it is unlikely that these waters could consistently contribute any very significant quantity of such fish for use as live-bait in tuna fishing; it seems clear that certain mainland waters, Port Phillip Bay in particular, would be much more suitable as centres for catching and penning anchovies for bait.

(iv) *Mullet Investigations.*—During the year the Division continued its general observational work on the biology of this species. Tagging work, which has been continued, has been extremely successful and has solved a number of problems that existed as to the behaviour of this fish. A proof that the mullet can travel large distances in a short time — for instance, 600 miles in 42 days—and a general confirmation of the theory established as to the growth rate of this fish, have been the major results. A further 87 tags have been returned since the completion of the first bulletin on the mullet. The market measuring carried on in the Brisbane Markets on a co-operative basis with the Queensland Department of Harbours and Marine has provided material for a fairly extensive analysis of the mullet stocks of Queensland waters. A report of this work is being prepared. An examination of the relationship between meteorological elements and the catch of this fish has, as yet, yielded no useful correlations.

(v) *Oyster Investigations.*—(*a*) *Spat Fall.*—The observations on fibro-cement sheets, established during 1941, and the commercial experiments with sticks and other materials, have been continued. In addition, the collection of plankton samples in an investigation of the distribution of larval oysters has been continued.

(*b*) *Fundamental Studies.*—(1) An experiment was carried out to determine the precise effects of an adverse environment on the growth of oysters. This experiment, wherein individual oysters are measured and weighed at regular intervals, has given information on the period of growth and relative growth of oysters in normal environment, as compared with the failure to grow in abnormal environment, and has yielded useful information on the relationship of certain biological indices, chiefly specific gravity, of whole oysters to growth and general health.

(2) Cytological and histological routine on samples of oysters taken regularly from standard stock has been continued.

(3) Planktological and hydrographical investigations of oyster-growing waters have been extended and are reported in the section on hydrographical investigations.

(*c*) *Winter Mortality.*—Material was set out in the winter of 1942 and was observed for the relationship of mortality to environmental factors.

(*d*) *Co-operation.*—N.S.W. State Fisheries Department provided funds during the year by which the Division was enabled to maintain basic studies in oyster investigations at the field experimental station at Shell Point. Contacts have been made with Oyster Farmers' Association of N.S.W. with a view to collaborating in observations on the growth and mortality of oysters in the course of commercial operations.

(vi) *Other Investigations.*—(*a*) *Minor On-Shore Species.*—The collection of data incidentally in the course of field work has been continued. This includes black bream and other on-shore species.

(*b*) *Snapper.*—The biological studies of this fish have been continued by a worker of Sydney University in collaboration with the Division and in co-operation with the N.S.W. State Fisheries Department. In addition, a student from the University of Western Australia, holding the Howlett Scholarship, has undertaken an investigational study of this species and is obtaining useful material on its growth rate, feeding habits, &c.

(*c*) *Black Fish.*—The intensive investigation of this species, of which material has been collected in the past years, has been undertaken by an additional biologist on the staff. Preliminary results on the growth rate, gonad development, &c., have been obtained.

(*d*) *Whiting.*—The investigation of material collected previously on this species has been undertaken by a second student of the Sydney University. His investigations have been continued at the Division's laboratory and in the field, and co-operation has been received from the N.S.W. State Fisheries Department. The work has had reference to taxonomy of the group, growth rate, feeding habits, ponderal index, &c.

(*e*) *Netting Experiments.* — The netting experiments undertaken in collaboration with the N.S.W. State Fisheries Department during 1941-42 have been continued as opportunity afforded. At the present stage there is evidence to indicate that in Australian in-shore waters the size characteristics of the catch are principally a function of the population being fished and have very small relationship to the type of net employed.

4. Plankton Investigations.

Since it is of great importance to maintain at least a minimum degree of continuity in the study of the annual cycle of variations in sea conditions, and the resultant effects on the plankton (including the eggs, larvae, and food of fishes), these investigations were continued on as adequate a basis as possible.

(i) *Marine Plankton.*—The examination of marine plankton from the *Warreen* tow-nettings (1938/1942) and of that from the stomachs of pelagic fish taken over the same period, continued. With the withdrawal of the *Warreen* in 1943, regularly fortnightly tow-nettings were made at the standard shallow station off Cronulla in order to preserve a minimum continuity.

(ii) *Estuarine Plankton.* — Hauls were made to test (*a*) the normal population, (*b*) the components brought in by the tide, and (*c*) the components moving out on the tide. The results, to date, suggest that eastern Australian waters are dominated by sub-tropical species, although there have been periods when species from somewhat cooler waters moved northwards. The northward extension of the range of the southern bluefin tuna has been coincident with this movement. When compared with the results obtained in cold waters in the Antarctic and in the Northern Hemisphere, the zooplankton of the eastern Australian waters appears to have a much more even breeding rhythm and a greatly reduced swarming intensity. A marked speeding up of the growth rate to maturity is apparent from south to north, while there appears to be a decrease in the oil content of crustacea in the same direction. However, in Tasmanian waters, there is a tendency toward more sharply defined breeding peaks in the crustacea, and also to an increase in the swarming intensity. It is noteworthy that in the zooplankton no one species is found to be dominant in the sense that *Calanus finmarhicus* and *Meganyctiphanes norvegica* are dominant in northern European waters.

5. Hydrological Investigations.

(i) *Oceanic.*—A continuous three-day sampling of oceanographical conditions at the on-shore Cronulla Station was carried out in July, 1942. The results from this survey were sufficient to demonstrate the rapidity with which oceanographical conditions can change in the on-shore waters at this location. It seems probable that these changes are connected with the off-shore movements of the large-scale eddies that exist in the waters of the S.E. Australian coast. As the oceanographical results obtained by M.V. *Warreen* at the Cronulla on-shore station were insufficient in any one year to derive a basic normal seasonal cycle, it was decided to work this station at fortnightly intervals, using locally-hired boats. This programme has been in operation since December, 1942, and some very useful data, not only for the building up of the seasonal cycle of conditions but also for the analysis of past data and of the general causes behind short-period variation in on-shore waters, have been obtained. Thus it seems clear that the rapid variations that occur off Cronulla are mainly due to the interaction of three different water masses, which completely obliterate each other, but by penetration at different levels, contribute in varying proportion to the oceanographical conditions therein. This possibly provides an explanation for the very diverse plankton community that is generally found at this station.

(ii) *Estuarine.* — Estuarine problems, concerned chiefly with the distribution and physiology of oysters, but also with the collection of fundamental data on estuarine hydrology which may be of assistance in elucidating problems connected with the breeding and migration of on-shore fish, have been studied. An extensive programme of research to provide the necessary data was drawn up and put into operation in June, 1942.

In Port Hacking the routine survey was supplemented at monthly intervals by a continuous 24-hour meteorological and hydrological sampling at the laboratory jetty. In Georges River the routine survey was extended up the river to Milperra, and a regular monthly survey of Botany Bay was commenced. The regular 24-hour observations at Shell Pt. were continued. A monthly survey of Pt. Stephens, together with simultaneous 24-hour observations at Karuah and Tea Gardens, was initiated.

Certain important conclusions are now possible. In the first place, taking Georges River as a typical estuary, it is possible to make a physico-chemical subdivision of this estuary into distinct zones in terms of chlorinity and chlorinity gradients, which

persist in spite of abnormal pressure from the seaward or freshwater side of the estuary. The physico-chemical properties of the zones seem capable of exact definition. The distribution of oysters seems to be associated with one of these zones.

Again certain puzzling features about the distribution of phosphates in estuarine waters have been largely cleared up by the discovery that, contrary to former opinion, flood waters are not deficient in phosphates (although high in nitrates) but contain large amounts of phosphates adsorbed on the colloidal mud suspended therein. This colloidal mud is agglutinated into a non-colloidal settling form as soon as the chlorinity rises above a low value, and is then rapidly deposited on the floor of the estuary. The phosphates remain adsorbed on the mud particles, but are readily liberated if the acidity of the mud is altered. If the oyster is able to make the change in the course of its digestive processes, an explanation can be offered of the general fact that the productive habitat of the oyster is always associated with these heavy black bottom muds. Thus the assimilation of particles of this mud would at a certain stage in the digestive cycle of the oyster yield relatively high concentration of available phosphates for immediate use.

The implication of this discovery in terms of the previously stated zonation seems clear and will be the subject of further experimentation. The routine collection of daily meteorological, hydrological, and continuous tide records has been continued in Pt. Hacking and at Shell Pt., Georges River. The water temperature records from Shell Pt. and Pt. Hacking are being subjected to harmonic analysis in an endeavour to discover whether hidden periodicities exist which could be directly linked with tidal and meteorological data.

6. Biometrical Studies.

(i) *General.*—A preliminary study has been made on the question of the significance of the coefficient of variation. Certain characteristics of this coefficient in relation to biological material have been made clear in this work. A study has also been made of the question of compensatory growth in fish, and it has been possible to indicate the nature of the phenomenon.

(ii) *Relationship Between River Flow and Catch of On-Shore Species.*—Data have been obtained from hydrological branches of Water Conservation Commissions in Queensland, N.S.W., and Victoria, and statistical analyses of these records by means of Fisher's polynominals and the correlation of the terms of these polynominals with the catch of various species of fish in in-shore waters have been begun. The earliest result reveals an inverse relationship between river flow and the catch of salmon in Victorian waters.

(iii) *Demersal Fisheries.*—The log books of the trawlers operating in the State Trawling Enterprise have been made available on loan by the N.S.W. State Fisheries Department. In addition, log books have been made available by two of the private trawling companies operating prior to this war. These records have been transferred to Powers Cards referring to individual catches, and analysis of these records has been made in the Powers Machine. Some valuable data on the yield per unit effort in the trawl fisheries on the coast of Australia have been extracted by this method. The variables under consideration include month or ground, time shot, fishing vessel, duration of shot, and quantity of fish taken in the haul. Although some analysis of the State Enterprise records has been made and published, the present investigation is making a more detailed inquiry and has the advantage of the more recent private enterprise records. The comparison of yield between the early years of this fishery and of the latest years is very striking.

7. Western Australian Branch.

Under ordinary conditions a Western Australian branch of the Division would have been set up some time ago. A separate investigation vessel, designed primarily for Danish seining experiments, had been projected, and laboratory facilities planned, at Fremantle. These proposals, after various modifications, lapsed owing to the war. However, a survey of the fisheries and marine conditions on the west coast, such as has been conducted in eastern Australia by the Division, is an obvious necessity, (*a*) on account of the very small industry at present existing, (*b*) since the area is a large one and has an extensive shelf in the north-west, and (*c*) since practically no real fishery investigations have been carried out hitherto. As a result of generous offers of co-operation by the Fisheries and Game Department of Western Australia, it has been decided to institute a branch of the Division in that State forthwith, and a senior member of the biological staff has been transferred from the laboratory at Cronulla to take charge at Perth, where he commenced duties at the beginning of May.

8. Aerial Observations.

During the years 1936-39, extensive aerial observations of pelagic or surface-swimming fish—those that frequent more or less habitually the upper layers of water—were undertaken by the Council's Fisheries Officer, Mr. S. Fowler, over the east and south coasts of Australia as far west as the head of the Great Australian Bight. The R.A.A.F. very kindly co-operated in this work and made aircraft and flying personnel available. These flights disclosed the presence of considerable quantities of pelagic fish, such as tuna, Australian salmon, and pilchards, in certain of our waters at certain seasons. Plans for an extension of the survey to Western Australia to start early in September, 1939, had naturally to be abandoned on the outbreak of hostilities because all available aircraft were required for urgent Defence purposes.

Recently, it has been found possible to make operational flights in certain areas of Australia. These flights, as their name implies, are not made specifically for the purpose of finding fish and, therefore, they are not so efficient as those in pre-war days when the aircraft provided were used solely for fishery observations. However, the privilege of accompanying operational flights has led to some very valuable observations being made. Apart from a series of flights between 5th and 20th March, 1943, over southern N.S.W., Victoria, Tasmania, and South Australia as far west as the head of the Great Australian Bight, the war-time aerial observations of fish have been confined to Western Australia. Nearly the whole of the waters of this State were covered by the flights on several occasions.

The flights in Western Australia disclosed considerable occurrences of various species of tuna and of mackerel (*Scomber australasicus*) and of another species of fish not previously observed in Australian waters from the air, the identity of which has not yet been definitely established. For security reasons, it is not considered desirable to publish at this stage the exact localities in which the above occurrences were noted. However, it is possible to say that they were within economic range of capture and treatment. The excellence of tuna for canning has, of course, been already established, and tests of the mackerel show that it, too, makes an excellent canned and smoked product.

Observations in Western Australia covered most of the months of December, 1942, to February, 1943, and April to June, 1943, and will be resumed at an early date so as to embrace the full seasonal cycle of the year. The results so far are very promising. Wherever possible the Department of Fisheries of Western Australia is arranging for a boat investigation of the occurrences discovered. One of the occurrences of mackerel was very large indeed, shoals being observed almost continuously for at least 50 miles. Photographic records have been obtained of this and the other occurrences referred to.

It is interesting to note that Japan is reported to be employing the aerial method of locating shoals of pelagic fish on an extensive scale. The system has also been introduced successfully in the United States of America. It is especially valuable to Australia where great areas of coastal waters have not previously been explored in a fisheries sense.

The Council warmly appreciates the co-operation of the R.A.A.F. in this work.

9. Miscellaneous.

(i) *Manpower.*—At the request of the Director-General of Manpower, the Division prepared a report on the productive capacity of the Australian fishery, on the minimal demands which it must meet in the present crisis, and on the way in which demands can be met with the least expenditure of manpower, fuel, equipment, transport, and distribution facilities. Upon receipt of this report the Director-General requested the Division to prepare a register of fishermen of the Commonwealth upon the basis of a questionnaire issued by his Department. This register has been prepared and the Division has submitted advice to the Director-General on the question of manpower in the industry. Further extension of this relationship to the fishing industry has occurred.

(ii) *General Survey of the Condition of the Australian Fisheries.*—Partly as a consequence of the information assembled in relation to the manpower register, and partly in response to needs within the Division, a comprehensive survey has been made of the existing fisheries of Australia, and all possible data have been accumulated. A report on the existing fisheries has been prepared from this material. Strong efforts have also been made to obtain the development of an adequate statistical system throughout the Commonwealth, and considerable advance has been made along these lines.

(iii) *Autumn School.* — Acting on a suggestion received from the Department of Biochemistry in the University of Sydney, the Division arranged an Autumn School in Oceanography. This School was attended by some 15 students accompanied by five lecturers. A course of lectures was delivered and some instructive practical classes were conducted.

(iv) *Enquiries.*—Throughout the year, miscellaneous ichthyological and fisheries' enquiries were dealt with. Amongst these may be mentioned:—

(*a*) Advice on the culture of the *Ava* fish (*Chanos*) for the Crown Prince of Tonga.

(*b*) Identifications of about 60 fishes from the stomach-contents of tunas, and smaller series from cormorants and other birds. Evidence obtained from the latter indicates that these birds are not destructive to valuable fishes. A list of vernacular names of Australian fishes was provided as a basis for further work. Its purpose is to stabilize the nomenclature of our food fishes which are at present known under conflicting names in different States. Much time and money are wasted through this confusion, the same names having been used for entirely different fish, or various fish having been confused under one name. Obviously statistics from the various States have proved difficult to compare on these accounts.

(*c*) *Poisonous Fishes.*—At the request of the military authorities, a report on poisonous fishes was prepared and published, chiefly for use by the Forces in tropical regions. The report, which is illustrated by coloured plates and black and white text-figures, was published as the Council's Bulletin 159. The distinguishing characters were given of fish which, while they may be attractive in appearance, are either poisonous to eat or inflict severe injuries by means of venomous spines; remedies for injuries were given.

X. NATIONAL STANDARDS LABORATORY.

1. General.

All the work undertaken by the Laboratory has a defence aspect and the expansion of activities has resulted in the complete use of all available accommodation. The equipment has been completely reorganized. The staff and equipment of the workshop have so expanded that a temporary wooden structure has been erected to provide woodworking facilities. The Laboratory is consulted considerably by other departments, production establishments, and laboratory workers.

2. Metrology.

(i) *General.* — Measuring equipment, gauges, sample components, and tools are examined on behalf of the Ministry of Munitions, the various Inspection Services, and manufacturing establishments. Volumetric glassware and analytical weights are calibrated and certified. The testing machines are calibrated mainly on behalf of the Inspection Services.

(ii) *Examination of Gauges and Measuring Equipment.*—Over 25,000 gauges were examined during the year. Not the least part of the work was training staff to enter a sphere to which they were totally unaccustomed.

Advice has been given to manufacturers and their equipment has been set up and tested in their works when necessary. Advice was given in the design, construction, and examination of measuring equipment, and personnel were trained for the gauge rooms of industrial concerns. Services of the staff have been made available for lectures in the training of factory inspectors in the course as taken by the Sydney Technical College on behalf of the Ministry of Munitions.

(iii) *Manufacture of Measuring Equipment.* — Production of bench micrometers, small projectors, and slip gauges has been undertaken on behalf of the Ministry of Munitions. In the case of measuring equipment, a prototype is built in the Laboratory, and then the services of sub-contractors are utilized with the manufacture of sub-assemblies. The final fitting assembly, lapping, and calibration are undertaken in the Laboratory.

(iv) *Calibration of Testing Machines.*—All Test Houses are periodically visited; personnel and methods are scrutinized and machines calibrated. Special equipment has been developed within the Laboratory for the examination of equipment accessory to mechanical testing.

(v) *Volumetric Glassware.*—As a result of assistance given, a local manufacturer has succeeded in producing a number of lines of laboratory apparatus to meet the requirements of British Standard Specifications. Further assistance is being given to enable a greater range of glassware to be produced.

(vi) *Mass.* — Demands for the certification of analytical weights are increasing regularly as the facilities of the Laboratory become known. Delivery of the standards of mass and balances from abroad is still outstanding.

3. Electrotechnology.

(i) *Equipment.*—The British Thomson-Houston Sine-Wave Alternator Set has been received and installed in the Laboratory. The equipment for the magnetic testing of iron has also been received from abroad, but has not yet been set up as it suffered slight damage in transit, apparently owing to faulty handling. A Sullivan Standard Condenser which was shipped from National Physical Laboratory, England, to the National Bureau of Standards, Washington, for additional tests, has arrived, but the Laboratory Standard of Inductance, which was also to be tested at the National Bureau of Standards before shipment to Australia, has not yet come to hand.

(ii) *Activities.*—Although confidential investigations undertaken on behalf of the three fighting Services continue to require almost the whole resources of the Section, a considerable number of D.C. electrical tests have been carried out during the year. As a result of the increasing demand, the establishment of the A.C. and audio-frequency testing facilities has been put in hand, and it should soon be possible for the Section to undertake a wider range of tests.

Thirty-three electrical indicating instruments of local manufacture were examined on behalf of the Ministry of Munitions. A number of serious faults were observed in the pivots, jewels, and springs of the meters, and the Laboratory has recently been requested to assist the manufacturers to improve the quality of their products. This project is being formally undertaken by the Electrotechnology Section, but arrangements have been made to co-ordinate several investigations in which all three technical sections of the Laboratory will be involved.

At a conference convened by the Scientific Liaison Bureau in Melbourne on May 14 to discuss the deterioration of equipment in the tropics, it was decided that the Council should be responsible for the co-ordination of work relating to electrical equipment. This responsibility has been delegated to the Electrotechnology Section. Discussions have already been held with officers of the M.G.O.'s Branch, Design Branch, Design Division, and with the newly-formed Mycological Panel, regarding the solution of immediate problems.

The Section was represented at a conference called by the Standards Association of Australia to consider the advisability of preparing Australian Standards for high-frequency ceramics. A Panel was formed to consider the adoption of the American War Standard for Class L Ceramic Insulating Material, and, at a meeting of this Panel, it was agreed to recommend endorsement of this American War Standard as an Australian Standard Specification.

A device for the automatic winding of resistance coils of high precision has been developed in the Laboratory. This device uses a new method for the automatic control of pitch, and will have wide applications, apart from the defence project for which it is being used at present.

4. Physics Section.

(i) *General.*—The work of the Physics Section has extended, particularly in the following three branches:—

(*a*) The calibration of pyrometric equipment, which has been carried out for the Ministry of Munitions since the end of 1940, has increased considerably during the current year. During this period the fighting Services have taken advantage to an increasing extent of the facilities available at the Laboratory for advice and assistance.

(*b*) Investigations and researches carried out as a result of the collaboration of the Laboratory with the Optical Munitions Panel, of which the Officer-in-Charge of the Section is a member, have formed a considerable part of the optical work of the Laboratory.

(*c*) During the year the photometric laboratory has been extended and considerably developed, and has been engaged on a wide range of investigations originating in the fighting Services and in industry. Many of these investigations have been carried out for the Vision Sub-committee of the R.A.A.F. Flying Personnel Research Committee on which the Laboratory is represented.

(ii) *Heat.*—The work of the Heat Section during the year has comprised the following:—

(*a*) *Pyrometric Calibration for the Ministry of Munitions.*—The Laboratory has continued to undertake the inspection and calibration of pyrometric equipment used in munitions factories and annexes in N.S.W. for the Ministry of Munitions. The work has extended during the year, and the factories in the Newcastle district have been included in the programme. The work has involved 175 visits during the year to factories and annexes, as well as the adjustment and calibration in the Laboratory of a large amount of pyrometric equipment.

(*b*) *Development of Local Manufacture of Pyrometric Instruments.*—The Laboratory has continued its assistance to firms engaged in the development and manufacture of pyrometric instruments. One type, in the development of which it has materially assisted, is now being extensively used in industry. These instruments have all received a thorough examination in the Laboratory.

(*c*) A number of persons from the Services and from industry have visited the Laboratory for extended periods to receive instruction in pyrometric technique.

(*d*) The melting point of gold defines an important fixed point of the International Temperature Scale. A furnace has been built for the maintenance of this point and has been tested at the melting point of copper with very satisfactory results.

(*e*) Other activities of the Heat Section included: the development of a psychrometer for the Operational Research Group for the measurement of humidity at high altitudes; advice to a local manufacturer on the construction of mercury-in-glass thermometers; assistance to the University of Queensland in the measurement of skin and body temperature in researches in tropical hygiene.

(iii) *Light.*—(*a*) *Optics.*—The principal activities of this section may be summarized as follows:—

(1) Assistance to the Optical Munitions Panel in the development of a gun-sighting telescope for the Navy.

(2) The development and construction of optical instruments, including the design and construction of a telephotometer for the Directorate of Camouflage, and the construction of 75 four-component projector lenses for a lumigauge required by the Directorate of Machine Tools and Gauges. This project is well on the way to completion.

(3) Investigations associated with the manufacture of optical glass in Australia:—Refractive index measurements of all melts of Australian made optical glass are regularly carried out by the Laboratory; a differential refractometer of high precision has been designed and constructed for rapid measurements of refractive index and dispersion of optical glass; investigations have been made by interferometer methods of the homogeneity of Australian optical glass.

(*b*) *Photometry.*—The photometric laboratory is now well equipped to carry out most standard photometric and colorimetric measurements. During the past year most of its activities were concerned with special problems associated with night vision in the Services and the measurement of illumination at very low intensities. These investigations include:—

(1) A night vision adaptometer for the measurement of the visual efficiency of personnel at night has been designed and supplied to the A.A.M.C. Research Unit, Victoria.

(2) Measurements have been made on the visible, ultra-violet, and infra-red absorption of a wide range of welders' goggles both from abroad and produced locally. It was shown that owing to lack of supplies many locally produced goggles did not adequately absorb the harmful radiations arising in gas and arc welding. Two specific problems in this field, the need for protective glasses for assistants to arc welders, and goggles suitable for special conditions in aluminium welding, were investigated and solutions found.

(3) At the request of the Department of Home Security, measurements were made at sea on the intensity of sky glow in the neighborhood of Sydney and of the effect of this on the range at which a ship can be detected from a submarine. These measurements at sea were supplemented by investigations in the Laboratory on models in which the actual visibility conditions were reproduced.

(4) The manufacture of fluorescent lamps gives rise to problems in photometry owing to the difference in colour temperature and spectral distribution of the light of these lamps and that of normal photometric standards. Assistance in solving these problems has been given to one of the principal lamp manufacturers.

(iv) *Electrical Standards.*—Work on the maintenance of the fundamental electrical standards of resistance and electromotive force show that these standards are being maintained at the Laboratory with a degree of accuracy which is very satisfying. A considerable number of tests has been carried out for various firms engaged in Defence work.

(v) *Jewel Bearings.*—The technique reported on last year developed in the Laboratory for the moulding of glass jewel bearings is now being used in mass production in industry.

XI. AERONAUTICAL INVESTIGATIONS.

1. General.

During the past year the Division has been active in fulfilling its double function of pursuing long range research on fundamental projects and of giving assistance on immediate problems to the Royal Australian Air Force, the United States Army Air Corps, and the Australian aircraft industry. For reasons of national security, no details of the work can be given and only a brief description of the main lines of investigation are given below. The provision of good sources of information is considered to be of primary importance. To this end, an effective interchange of research information is maintained with England, Canada, and the United States, supplemented by a well equipped library and detailed index systems.

2. Structures and Materials Section.

The main developments have been in the use of Australian timbers for aircraft. Design data have been obtained for both conventional and moulded wood construction, both long range fundamental aspects and developments of immediate practical importance being given attention. In addition, structural and material tests of a wide variety have been made for the aircraft industry, and the causes of aeroplane accidents determined. Metallurgical research work has been carried out in the fields of fabrication, powder metallurgy, and corrosion. The properties of Australian aircraft steels have been investigated in detail, and examinations made of faulty materials and captured enemy aircraft and engines.

3. Aerodynamics Section.

A great deal of model testing and developmental work for the aircraft industry has been carried out in the wind tunnel. Long range investigations have been continued on the design of fans and ducts, and the results already obtained have been applied in specific problems of cooling aero and automotive engines. Fundamental research in the fields of boundary layer flow, compressibility, and turbulence have been carried out with a view to its application to the problems of high speed flight. A second wind tunnel in which the pressure may be varied and high speeds of air flow obtained, is being constructed to obtain experimental data applicable to problems of propulsion and high speed flight. Performance testing of aircraft in flight has also been carried out for the R.A.A.F.

4. Engines and Fuels Section.

The engine testing equipment has been completed and a very comprehensive range of engine test beds is now available. All types of aero, tank, and automobile engines can be accommodated. The greater part of the work done during the year has been the testing of aero engines, both allied and captured from the enemy. In addition, tests of engine components, fuels, lubricants, and materials, and developmental tests on small stationary petrol engines for Army use have been made. Two long range investigations have been proceeding; the first is on the development of the McLaren rotary valve engine, and the second on the problem of excluding dust from engines by the provision of suitable air cleaners in the intake. The most fruitful field of invention is the internal combustion engine, and, on an average, one or two inventions per week are submitted by the Army Inventions Directorate for examination and assessment.

5. Instruments Section.

The work of this section is divided into two parts. The first is the design, construction, and development of special research instruments which are required by the other sections, or by the Services. The other branch of work is the type testing of aircraft instruments, chiefly of local manufacture. Captured enemy instruments have also been tested.

XII. INVESTIGATIONS IN INDUSTRIAL CHEMISTRY.

1. General.

Established in war-time and having had its own laboratory only for a little over a year, the Division of Industrial Chemistry has already been given ample opportunity to demonstrate its usefulness to other Government Departments, to the Services, and to industry. Apart from the research projects enumerated hereafter, and others of a confidential nature, the Division's officers are frequently called upon for technical advice by other Government Departments, especially Munitions, and Supply and Shipping. It has supplied to them information regarding production and the use of chemicals in Australia, the use of substitutes for materials in short supply, and the suitability of local raw materials or intermediates for the production of munitions and essential goods.

Where advice is sought concerning the establishment of major industries, especially if novel processes have been proposed, much work may be involved by the officers of more than one Section. The Services and industry are also making increasing use of the Division, and advisory services have now become a major activity.

With labour and building materials in short supply, the erection of the main laboratory, with its manifold services, occupied much longer than was estimated by the architects. It was filled to capacity almost as soon as it was opened, and there has been serious overcrowding in recent months. Extensions authorized about the middle of 1942 have been planned to provide laboratory facilities alongside pilot plant investigations. Of simple design, they have been built with reasonable speed, and it is anticipated that they will be ready for occupation in August, 1943. A number of pilot plants for which equipment has already been designed and fabricated will be erected immediately.

The Chief of the Division is a member of the Industrial Chemicals Committee, which was created late in 1942 by the Department of Munitions under the chairmanship of Mr. A. E. Leighton. Mr. E. J. Drake, an officer of the Division who is seconded to that Department, is the secretary of this Committee, which acts in an advisory capacity on questions related to such industrial chemicals as are essential to the war effort, supplies, stores, manufacture, and imports. Close connexion with this committee ensures that in choosing its research projects the Division has access to authoritative information. Several of the projects initiated prior to its inception have been sponsored by the Committee, and work on others has been expedited at its request.

The Rubber Advisory Committee set up by the Council during the preceding year, to assist in conserving supplies of rubber, continued to function until a committee with wider terms of reference, known as the Rubber Industries Technical Committee, was set up by the Department of Supply and Shipping. The Chief of the Division acts as Chairman of this Committee, to which all technical questions concerning natural and synthetic rubber are referred. The Organic Chemistry Section of the Division has repeatedly been consulted on matters concerning synthetic rubber; this Section and the Biochemistry Section are both engaged in research projects in this connexion, and a co-operative investigation with the University of Melbourne is about to be undertaken. Certain investigations on the recovery of rubber from *Cryptostegia* at the University of Sydney are also financed from the Division's vote.

There are three activities of the Division which are not housed in its Laboratory. The Biochemistry Section, formerly known as the Section of Leather and Fellmongery, is housed at the Melbourne laboratory of the Division of Animal Health and Nutrition. The Foundry Sands Section is housed at the Melbourne Technical College, and in Western Australia two officers of the Division have continued to assist the University in research aimed at the exploitation of the extensive alunite deposits of that State.

A canteen, shared by the staff of the Division with the Division of Aeronautics, was opened near the commencement of the year under review. This amenity is greatly appreciated; it is controlled by a committee representative of all sections of the staffs.

The description which follows of the activities of the various Sections focuses attention on the work of the scientific and technical officers. The essential part played by the clerical and stores staffs and by the tradesmen and labourers is recorded with appreciation by these officers.

2. Dairy Products.

The Division's officers have worked as a joint team with the Council's Section of Dairy Research. Their work is described in the report of that Section.

3. Biochemistry Section.

Though the Section has continued to devote much of its time to research designed to assist the fellmongering industry, its officers have been called upon for assistance in several other directions. The name of the Section has therefore been changed (see above).

(i) *Fellmongering Research. — (a) Physical Method of Following the Depilation of Sheepskins.*— The magnitude of the depilation load (see 16th Annual Report) is reduced by rise in temperature of the skin.

(*b*) *Mechanism of Sweating.*—Spontaneous degradation of the tissues in sterile foetal lambskin during 64 hours' incubation at 25° C. has been detected by measuring the increase in non-protein nitrogen. No similar degradation was detectable in adult sheepskin which had been sterilized by chemical means.

(*c*) *Pelt Damage During Sweating.*—Continuation of the work on the causes of pelt damage has shown that one species of bacterium, a *Clostridium,* produces damage both in the presence and absence of nematodes. Methods of preventing damage by impregnating the skins with chemicals before sweating are under investigation.

(ii) *Leather-Plastic Prepared from Scrap Leather.* —The plastic containing finely-ground vegetable-tanned leather, linseed oil, animal glue, and a trace of potassium dichromate, has been found to possess high electrical resistance. The possibilities of manufacturing the material on a commercial scale are being explored.

(iii) *Fermentation Research. — Production of Lactic Acid by Fermentation.*—Work is in progress on the production of lactic acid from whey by fermentation with *Lactobacillis bulgaricus.* The particular aspects being investigated by this Section are the effect of nutrients on the time for complete conversion of the lactose to lactic acid. Other aspects are being investigated by the Council's Dairy Section.

(iv) *Proteolytic Enzymes.* — Enzymes are being used in increasing quantities in a wide variety of industries, and the Section will, in future, regard this part of its work as a major activity. The viscosity of a gelatin-enzyme mixture after 10 mins.' incubation at 40° C. has been selected as a measure of the activity of an enzyme.

(*a*) *Euphorbain, a Proteolytic Enzyme from Euphorbia lathyris.*—Investigations on euphorbain have been extended to a study of the effect of activating and reducing agents and the optimum pH value. The gelatinase and rennase methods have been used for assessing its potency as an enzyme.

(*b*) *Papain from Australian Sources.* — When dried by spreading in a thin layer on glass or by the addition of acetone or alcohol, papaw latex collected at Nambour, Queensland, yielded papain of high gelatinase and rennase activity. Juice pressed from the skins of the fruit possessed higher activity than that from the flesh, while seed extract possessed no measurable activity. The activity was of the same order for papain from different species of trees.

(v) *Substitute Container Investigations.*—Because of the shortage of tinplate the Council was asked by the Commonwealth Tinplate Board to evaluate the suitability of a number of substitute containers for the package of foodstuffs. This work has been done in close collaboration with the Division of Food Preservation and Transport.

Studies have been made of the melting points of many waxes and wax mixtures, with a view to determining which are most suitable for proofing substitute containers for hot-filled foods and for use in hot climates. This work has revealed many interesting points, for example, the addition of 10 per cent. of the high melting wax shellac to the lower melting paraffin wax raises the melting point by 10° C. Measurement of the pliability of wax films applied to kraft paper has shown that the addition of up to 5 per cent. of butyl stearate, castor oil, and wool wax, to paraffin wax and to mixtures of paraffin wax and hydrogenated oleo-stearine did not improve the pliability.

Water vapour permeability measurements have shown that waxes containing polar groups such as sugar cane, gram, and shellac are more permeable than paraffin wax. Wool wax was the only material of those examined which lowered the permeability of paraffin wax.

A spiral-wound container, which was developed in co-operation with Sands & McDougall Pty. Ltd. from laminated bitumen paper, glassine, and flushed internally with wax, offered a high degree of protection against water vapour and may be suitable for hygroscopic materials such as skim milk powder. A lap-wound paper container, suitably proofed to prevent penetration of jam through the wall, and coated externally after filling to prevent drying, may be adopted for jam.

Portion of this work, together with results obtained in the Council's Food Preservation Laboratory, Homebush, is described in Part II. of the Tinplate Substitute Container Committee Bulletin No. 1.

4. Minerals Utilization.

The work of the Minerals Section is designed to assist in the commercial utilization of Australian minerals by devising and adopting chemical treatments necessary for the production of a wide variety of chemical compounds and industrial intermediates from crude ores and minerals. In the period under review, the minerals which received the main attention were as follows:—Chromite, monazite, fluorite, bauxite, graphite, pyrolusite, rutile, beryl, and rock phosphate.

(i) *Chromite.*—The investigations on the production of chrome chemicals from chrome ore by a novel process using direct acid attack on the mineral have been continued. The process is applicable to a wider variety of chrome ores than is the usual method, and therefore some Australian chrome ores hitherto rejected for chemical use are amenable to treatment. The method followed aims at the production of chromic anhydride, which is a versatile intermediate leading to the production of chrome plating salts, tanning compounds, essential pigments, chrome khaki dyes, bichromates, etc. A high priority rating has been granted by the Industrial Chemicals Committee for this project. The work has reached a stage when pilot plant tests, designed to produce about 30 lb. of chromic anhydride a day, will soon be instituted.

(ii) *Monazite.*—The work on the preparation of anhydrous rare earth chlorides from monazite for pyrophoric cerium-iron alloy production has been subordinated to investigations covering the preparation of mixed rare earth fluorides, thorium derivatives, and those rare earth compounds used in the production of special types of optical glass. The laboratory investigations have led to the design of a comprehensive and adaptable process for the chemical treatment of monazite ore for production of one or more of the above products at will. Pilot plant equipment for larger scale investigation of the process is being assembled.

(iii) *Fluorite.*—The investigation on the synthesis of cryolite by various methods using high-grade fluorspar as one of the raw materials has been continued. Difficulties have been encountered owing to contamination of the various products with silica introduced inadvertently with the fluorspar. Chemical and physical methods of avoiding this disability have been investigated. A subsidiary project concerning the production of aluminium fluoride has been combined with this investigation. The work devolves largely on the projected manufacture of aluminium in Australia, but is also concerned with an extension of the uses of fluorspar in the production of other chemical intermediates.

(iv) *Bauxite.*—Investigations on the treatment of bauxite from near Boolarra, in Gippsland, undertaken at the request of the Department of Supply and Shipping, have been continued to ascertain its suitability for treatment by the Bayer process for alumina manufacture. Methods for elimination of dissolved silica have been studied, as have the conditions for precipitation of the alumina from the solutions obtained. A decision as to conditions under which aluminium manufacture is to be undertaken in Australia will determine the future planning of this work.

(v) *Graphite.*—Work has continued on the assessment of the qualities of Australian graphite. Methods for removal of certain impurities by chemical means have received most attention. The performance of prepared samples in electrical dry cells has been encouraging. In addition, the work has included a study of the possibilities of preparing colloidal graphite by appropriate dispersion of the processed mineral concentrate.

(vi) *Pyrolusite.* — The chemical factors which influence the performance of some Australian manganese dioxide ores in electrical dry cells have been studied. Attention has been focused on the possibility of using the by-product manganese dioxide mud obtained at the works of the Electrolytic Zinc Company in Tasmania. In its untreated form, this material is unsuitable, but chemical beneficiation is being attempted. Studies of the "activities" of the various products have been made.

(vii) *Rutile.* — The studies on chlorination of refractory minerals mentioned in the last report have been extended to rutile. The factors influencing the production of titanium tetrachloride from rutile have been fully investigated on both the laboratory and pilot plant scale. Comparative tests have indicated that ilmenite is less satisfactory as a source of titanium tetrachloride than rutile. The rutile and ilmenite used in these tests were from the important deposits on the northern beaches of New South Wales. Apart from the uses of titanium tetrachloride as such, some preliminary work was undertaken on certain derived products of industrial significance.

(viii) *Beryl.*—Various methods have been examined for the extraction of beryllium compounds from beryl ore. Two bulk samples of Australian beryl of different composition have been tested and novel methods of extraction investigated.

(ix) *Rock Phosphate.*—A thorough investigation was made of the practicability of preparing phosphorus oxychloride by the chlorination of a dry and heated mixture of rock phosphate and carbon. The operation was carried through to pilot plant stage. At the expense of some inefficiency of chlorine utilization, this method of production was shown to be quite satisfactory when more convenient sources of this important intermediate are unavailable.

(x) *Miscellaneous.* — In addition to the regular investigations outlined above, a wide variety of enquiries on the utilization and chemical processing

of Australian minerals has been dealt with. Industrial contacts have been maintained and developed as opportunity offered.

5. Cement Section.

The main investigations of this Section are connected with the role of the alkali metals, potassium and sodium, in portland cement. The work is being carried on in collaboration with the Australian Cement Manufacturers' Association, which is contributing liberally towards the establishment and maintenance costs of the Section.

Observations recently made abroad have suggested that in certain circumstances the presence of more than the average amount of alkali metals in portland cement is undesirable. Since this matter is regarded as urgent, most of the Section's activities are being diverted towards its elucidation. A wider range of investigations is contemplated for a later date.

(i) *Clinker Investigations.* — The potassium and sodium compounds in portland cement clinker are being investigated petrographically and chemically. A wide range of commercial clinkers has been examined by these methods. Attempts are also being made to devise methods by which the alkali metals would be eliminated from clinkers or rendered inactive.

(ii) *Concrete Investigations.*—The suggestion that certain types of aggregate may react with high-alkali cement and cause dangerous expansions in concrete has recently received a great deal of attention. The matter is being investigated using Australian cements and a wide variety of Australian aggregates. Direct methods of measuring expansions in test bars require a considerable time before significant results can be obtained. Attention is being given to devising more rapid methods for detecting reactive expansion.

(iii) *Soil-Cement Pavements.* — An investigation into the effects of using portland cements of different compositions in soil-cement mixtures will shortly be commenced.

6. Physical Metallurgy Section.

The whole of the research work in physical metallurgy of both the Divisions of Industrial Chemistry and Aeronautics has been consolidated in one Section of Physical Metallurgy which, for administrative purposes, is regarded as being within the Division of Industrial Chemistry. The sub-section of the Division of Industrial Chemistry, which was established early in the year under review, has been chiefly concerned with five major research projects, some of which are confidential. However, time was found for the investigation of some minor problems which were submitted by other Sections, by Government Departments, and by private organizations engaged in war work.

(i) *Conservation of Tin.*—(*a*) *Solders.*—At the request of the Assistant-Controller, Non-Ferrous Metals, a study was made of means of conserving tin used in solders. Concurrently with a review of the literature on similar investigations carried out in England and America, an experimental study of low-tin and tin-free solders was made. This provided the information published in Industrial Chemistry Circular No. 2, in which it was shown that for the majority of purposes, solders with little or no tin can be employed successfully in place of 50/50 and 40/60 tin-lead alloys. The contamination of canned foodstuffs by the corrosive extraction of metal from substitute solders was investigated in conjunction with the Analytical Section. From time to time, the Assistant Controller, Non-Ferrous Metals, was advised on technical problems relating to the issue of the "Control of Solder Order."

(*b*) *Bearing Metals, Casting Alloys, etc.*—In connexion with the steps taken to replace tin-base babbitts by lead-base babbitts, the Section acted in association with the Lubricants and Bearings Section.

(ii) *Surface Tension of Liquid Metals and Alloys.* —A programme of research on the surface tension of liquid metals and alloys was undertaken in an endeavour to throw some light on our knowledge of liquid metals, both from the point of view of their structure and their behaviour in processes such as casting, soldering, and welding.

Liquid alloys in the cadmium-antimony and lead-antimony series were studied by means of the maximum bubble pressure method. Besides yielding confirmation of earlier work of overseas investigators, results obtained to date presage some interesting and useful discoveries. The preliminary results are being published.

(iii) *Miscellaneous Problems.*—Advice on the production of aluminium-manganese and copper-manganese hardener alloys from pyrolusite and Risdon anode mud was given to a representative of the Directorate of Materials Supply, and to one of the leading non-ferrous foundries. Data of practical value were obtained from some experimental work on the alumino-thermic reduction of manganese oxides.

At the request of the Standards Association of Australia, methods for determining the thickness of tin coatings on copper and brass were worked out.

7. Physical Chemistry Section.

(i) *Flotation Researches.*—(*a*) *Flotation of Sulphide Ores.*—The anionic products of oxidation of sulphide minerals of copper, lead, zinc, and iron have been shown to exert no detrimental effect on the flotation of galena (PbS), chalcopyrite ($CuFeS_2$) and sphalerite (ZnS). On the other hand, surface oxidation affects the flotative properties of these minerals. The theoretical conditions for separation of a mixture of oxidized and unoxidized ore have been applied to synthetic mixtures. Results are sufficient to show that there are other factors to be elucidated before the theory can be directly applied to practical separation.

(*b*) *Flotation of Tin Ores.*—The preliminary work on the flotation of cassiterite (SnO_2) is complete. The reagent and conditions found have been applied to Australian ores with some success, and it is hoped that pilot plant work will commence in the near future.

(*c*) *Flotation of Bauxite and Alunite.*—Flotation beneficiation of these minerals has not proved encouraging, but it is intended to persevere with bauxite.

(*d*) *Separation of Ergot from Rye Grain.*—Flotation has been successfully applied to the separation of ergot, a fungus supplying the drug ergot, from rye grain. The whole of this year's crop has been separated in a pilot plant.

(*e*) *Flotation of King Island Scheelite.* — The important factors in the flotation of scheelite ($CaWO_4$) by oleic acid were determined. Further, a new reagent has been developed which shows considerable promise for tungsten production.

(*f*) *Insoluble Material from Salt.*—Because of a shortage of salt for industrial use, a flotation method was developed for removing gypsum and silica from salt deposits. The method is expensive when judged on current salt prices.

(*g*) *Flotation of Graphite.*—Methods of floating some Australian graphites have been investigated, and it has been shown that the grade of Australian commercial products can be considerably raised.

(ii) *Production of Acetone from Vinegar.*—The extraction of acetic acid from vinegar by benzene and subsequent extraction of the acetic acid by lime

was shown to be feasible. This investigation was not completed, the supply difficulties which prompted the investigation being now overcome.

(iii) *Spectrographic Investigations.* — The composition of impurities in aluminium oxide for aluminium production has been investigated.

(iv) *Removal of Carbon Deposits from Aeroplane Engines.*—Carbon deposits on aero engines provide a serious problem in aircraft maintenance. Chemical and physical methods of removing deposits are being investigated.

8. Foundry Sands Section.

The principal activity of the Foundry Sands Section has been the carrying out of surveys of moulding sand deposits in South Australia and New South Wales. These surveys have been co-operative projects with the Mines Departments in the States concerned. Advisory work to foundries has been continued, and a comprehensive reference index of literature on foundry practice and allied subjects is being maintained.

(i) *Melbourne Sands.*—In May, 1942, it was proposed that the distribution of moulding sands should be rationalized, and a report on the various sands available was requested. A draft report was prepared for use by the Department of War Organization of Industry and the Moulding Sands Suppliers Committee.

(ii) *Adelaide Sands.*—A survey of sands in South Australia is being undertaken jointly with the South Australian Mines Department. The various pits were visited with a representative of the Mines Department; samples were obtained and forwarded to Melbourne for testing. Tests have now been completed, and it is hoped to publish a report on the survey shortly.

(iii) *New South Wales Sands.*—As a result of preliminary talks the members of the Foundrymen's Association, the Ministry of Munitions and the New South Wales Mines Department, it was decided to carry out a survey of sands in New South Wales in order to bring up to date an investigation made in 1931, and present the information with complete American Foundrymen's Association routine tests. The field work for this has been completed, and samples have been forwarded to Melbourne for testing.

(iv) *Western Australian Moulding Sands.*—The State Committee of the Council has requested that a survey of Western Australian moulding sands should be carried out, and that foundries should be visited in that State. Preliminary arrangements for this survey are being made.

(v) *Testing of Clays.*—A number of clays submitted as substitutes for Wyoming bentonite have been tested. Some of these show considerable promise, in particular a Western Australian clay was favourably reported on by foundries to which samples were submitted for plant scale tests after laboratory tests had indicated satisfactory bonding properties.

(vi) *Miscellaneous.*—Zircon flour has been tested both in washes and as a mould ingredient. Australian sands have been tested for suitability for use in the production of magnesium alloy castings. Numerous other minor investigations have been carried out.

9. Organic Chemistry Section.

(i) *Ethylene and Its Derivatives.* — Based on experience gained with laboratory apparatus and in conjunction with the Chemical Engineering Section, a pilot plant for the production of ethylene (output about 100 cu. ft. per hour) has been constructed and has been operated for some time.

After studying the formation of ethylene chlorhydrin on a small batch scale, its preparation by a continuous process has been examined in the laboratory and a pilot plant for its production in this manner is in course of construction. It is considered that many of the mechanical difficulties associated with the batch preparation will be eliminated in this way. On a large laboratory scale, very good yields of ethylene oxide have been obtained from ethylene chlorhydrin. The preparation of $\beta\beta'$-dichlorodiethyl ether has been carried out on a small scale; this compound is used in the production of one type of synthetic rubber of the thioplast type.

The apparatus for investigating the catalytic oxidation of ethylene to ethylene oxide has been completed; it allows of automatic control of the reaction gas composition, and the reaction temperature is maintained and regulated by means of a Dowtherm boiler system. Various catalysts are under examination.

(ii) *Synthetic Rubber of Thioplast Type.*—Small-scale preliminary preparations of this type of rubber have been made. The products have been tested in collaboration with one of the rubber companies. The work in this field is complementary to that of commercial organizations now producing "Thiokol" in Australia.

(iii) *Synthetic Resins.*—The phenol and cresol-formaldehyde types have been investigated mainly for the purpose of discovering resins suitable for the production of compregnated woods and as hot glues for plywoods, compregnated woods and wood-metal joints. A wide range of resins have been prepared and analysed. A method of analysis developed in the laboratory also gives valuable information even when applied to resins of outside origin. Suitable resins have been submitted to the Division of Forest Products, which has continued to examine the relationship between compregnated wood strengths and resin composition. Large quantities of a selected standard resin have been supplied to the same Division, thus enabling it to discover the most satisfactory technique for the production of compregnated woods. The resins selected for compregnated wood manufacture have been prepared on a large scale (100 gallons), and the woods produced have been shown to be suitable for use in aircraft construction. Details for the preparation of these resins have been circulated to manufacturers, and the resin has been produced commercially.

The phenol-formaldehyde resins, including the cast phenolic type, have been further studied to develop water and mould-proof glues for plywoods and compregnated woods which cure at about 100° C. Preliminary results in this field have been promising; the glues far excel animal glues (casein, blood albumen) in strength and water resistance. It is hoped to develop glues equal to the best commercial glues of this class.

Aniline-formaldehyde resins, though less known than the phenol-formaldehyde class, are superior to the latter as moulding powders for some electrical work, and, when used in conjunction with them, are reported to give the strongest adhesives for compregnated woods. Resins for both of these purposes are being developed. The Division of Forest Products is testing the gluing properties of the resins prepared.

(iv) *Furfural.*—The preliminary laboratory work required for the study of the preparation of this compound on a small pilot plant scale has been completed, and in collaboration with the Chemical Engineering Section, plans have been drawn for this plant. During the laboratory work several gallons of furfural were obtained; this has been used either in the study of furfural derivatives and in the preparation of phenol-furfural resins or supplied to industries using this chemical. The small amounts

thus available were instrumental in keeping one small but essential industry operating for two months until commercial supplies were available.

(v) *Analysis of Cracked Tar Gases.*—This investigation has received financial aid from the National Gas Association of Australia. Gas produced by the high temperature cracking of tar oils will be submitted to complete analysis. The analysis involves their liquefaction and fractional distillation followed by chemical analysis of the individual distillates. The complete apparatus has been constructed and is being assembled and tested.

(vi) *Synthetic Waxes.*—Surplus fatty acids are being examined as possible sources of substitute waxes. Waxes have been prepared from coconut oil acids, from tallow acids, and from commercial stearic acid. They vary in melting point from 55° to 78° C. and have negligible acid numbers. Samples have been submitted to various wax users to discover the extent to which they may replace waxes now used and in short supply. The methods of preparation are at present still being developed at the laboratory stage.

(vii) *Mannitol.*—Some 50 years ago, manna from the tree *Myoporum platycarpum* was stated to contain mannitol. This manna, and the exudation from which it is produced by evaporation, has been examined as a possible Australian source of mannitol. A method of estimating the mannitol in the exudation has been completed, and the isolation of the material on a small pilot plant scale is under investigation. At present, supplies of the manna are obtained by collection from accidentally-infected trees, but, in collaboration with the Botanical School of the University of Melbourne, the possibility is being investigated of infecting the trees with the exciting organism. Mannitol and its derivatives have a rapidly extending range of uses. Production by synthetic methods commenced in U.S.A. in 1936 and is now in the region of 2,000 tons annually. Previously this chemical was produced in Sicily by daily incision of the tree *Fraxinus ornus* during the summer months, the average annual yield from one tree being about 20 g. of a manna of varying mannitol content. One tree of the Australian species has so far, in eight months, produced exudation containing 8 lb. of mannitol without incisions.

(viii) *Utilization of Ortho-Cresol.*—A short series of investigations carried out in collaboration with the Division of Forest Products concerned the production of some derivatives of o-cresol of commercial value. Ortho-cresol proved unsuitable as a source of salicylic acids, since yields reached only 31 per cent. of the theoretical, and the much greater yields reported in the literature could not be confirmed. On the other hand, 3:5-dinitro-o-cresol was shown to be readily prepared.

(ix) *Miscellaneous Investigations.*—These include the analysis of materials used in the construction of enemy aeroplanes, the investigation of flash points and other properties of trichlorethylene and white spirit mixtures, the examination of various vegetable oils, the preparation of high aliphatic amines for flotation work, the estimation of anabasine in *Nicotiana glauca,* and the moulding of various test pieces from commercial moulding powders. Several minor *ad hoc* investigations have also been undertaken for the aircraft industry.

10. Chemical Engineering Section.

During the year 1942-43 much pilot plant has been designed and fabricated on the site. Other plant is being built to the Section's designs by engineering firms. Work has been carried out on the following projects:—

(i) *Woolindras Treatment of Knitted Woollen Goods and Woven Fabric.*—Work on this project was restricted to helping Kelsall & Kemp (Tas.) Ltd. during the initial stages of the operation of the Woolindras plant at their mill in Tasmania. This project may now be regarded as completed.

(ii) *Freney-Lipson Treatment of Knitted Goods.*—A pilot plant has been built and is now being operated for the treatment of knitted woollen goods by the Freney-Lipson process. The plant was designed to reduce handling of the goods and the alcohol vapour-nuisance to a minimum. Results obtained so far are good.

(iii) *Ethylene.*—During the year a pilot plant to produce ethylene at the rate of 100 cu. ft. per hour has been operated. The ethylene is produced by passing alcohol vapour over a clay catalyst heated to 360–380° C. Some work remains to be done on improving the clay catalyst which at present has rather a short life. Data have, however, been collected which will be useful in designing larger plant.

(iv) *Ethylene Dichloride.*—A pilot plant has been built and operated for the production of ethylene dichloride at the rate of 10 lb. per hour by the chlorination of ethylene in the presence of a lead catalyst. The ethylene dichloride has been used for the production of thiokol; it may also be used for the solvent extraction of Vitamin A. A quantity was produced specially to assist the Universities in research work on essential drugs; if it had not been available there would have been considerable delays.

(v) *Chromic Anhydride.*—A pilot plant capable of treating at least 50 lb. of chromite per batch has been designed, and most of the equipment required is completed or is nearing completion. The plant will be erected and operated within the next few months.

(vi) *Furfural.*—Pilot plant equipment is being manufactured for the production of furfural from oat hulls and other cellulosic materials. A fractionating column for concentrating aqueous furfural has been designed and manufactured. This column should be capable of continuously distilling at least 5 lb. of "wet" furfural per hour, from a feed containing 4 per cent. furfural. The autoclave required for producing the furfural is in the course of manufacture. A larger autoclave capable of producing 20 lb. furfural per four-hour period is at present being designed.

(vii) *Gottschalk Fermentation Process.*—The pilot plant is almost completed; when it has been erected and tested it will be handed over to the Biochemistry Section.

(viii) *Purification of the Permanent Salt from the Pink Lakes, Vic.*—The possibility of purifying the permanent salt from the Pink Lakes near Underbool, Victoria, by a simple washing process was investigated. Although a marked improvement in appearance could be effected by crushing and washing the salt with brine, the insoluble impurities such as gypsum were not reduced sufficiently to make the salt of general use. Further efforts to purify the product are described elsewhere.

(ix) *Dowtherm Heating.*—An investigation into the special methods required for preventing leakage in "Dowtherm" systems has been carried out. The methods ultimately adopted for making joints and for pumping the hot Dowtherm liquid have proved entirely satisfactory, and have now been incorporated in a small-scale plant designed to produce ethylene oxide.

(x) *Rare Earth Oxides from Monazite.*—A pilot plant has been designed for the preparation of rare earth oxides by the sulphuric acid digestion of monazite. This plant will have a capacity of about 50 lb. of rare earth oxides per batch. Consideration

has also been given to the possibility of converting the rare earth oxides to rare earth fluorides on a pilot plant scale.

11. Analytical Section.

The Analytical Section has provided analytical assistance in connexion with many of the investigations cited under the Sections of Minerals Utilization, Physical Chemistry, and Physical Metallurgy. It has not yet found time to conduct much analytical research, but it has played the major part in an investigation of the uptake of lead and copper from various substitute solders which had been proposed for use in the canning industry. The results have been published.

XIII. LUBRICANTS AND BEARINGS.

1. General.

Progress has been maintained in the general work of the Section, and the expansion of this work and the development of new lines have necessitated an increase in staff and the design and construction of new equipment. At the present time the Section is engaged primarily on war work and, since a great part of this is confidential, it is not described here.

The University of Melbourne is continuing its collaboration. Professor E. J. Hartung has provided valuable assistance as well as additional laboratory space and facilities in the Chemistry School. The Departments of Engineering, of Physics, and of Metallurgy are also helping with different aspects of the work.

2. Lubrication.

The laboratory has been equipped with special apparatus constructed for the physical and chemical investigation of lubricants and lubricating oils. A number of investigations are in progress.

(i) *Mechanism of Lubrication.*—Investigations are continuing into the mechanism by which the boundary lubricating film reduces the friction between sliding metal surfaces. Earlier work showed that polar molecules which are highly orientated are, as a rule, good boundary lubricants. More recent work has indicated, however, that a lubricant is effective under boundary film conditions, only if it enters into chemical combination with the metal surface. These results are of interest both from the fundamental and from the practical point of view.

(ii) *The Influence of Temperature on Lubricants.*—In general, boundary lubricants break down under extreme running conditions owing to the frictional generation of heat which causes a deterioration in lubricating efficiency. Using the friction apparatus developed for analysing the friction between slowly running surfaces, the effect of temperature on the boundary lubricating properties of various materials has been investigated. This has helped to clarify the basic mechanism of boundary lubrication. It has also enabled oils and greases to be selected in order of their lubricating properties.

(iii) *Cylinder Lubrication in a Running Engine.*—Investigations are being continued into the conditions of lubrication between the piston ring and cylinder wall of a running engine. The experimental method consists essentially of an analysis of the electrical conductivity across the oil film between the moving piston ring and the cylinder wall. If the conditions are those of fluid lubrication, the electrical resistance of the contact will be high; when however the film breaks down and metallic contact occurs, the resistance will fall to a low value. The resistance is measured on a cathode ray oscillograph which may be synchronized with the stroke of the engine and which is capable of recording very rapid changes in resistance, so that the lubricating conditions can be analysed in considerable detail at all stages of the cycle. By use of this method, more precise information may be obtained regarding the various factors, *e.g.*, speed, and temperature and viscosity of the oil, which influence the breakdown of the oil film. So far the experiments have been made on a small single cylinder engine of low horsepower, but the method could without serious difficulty be applied to most engines.

(iv) *The Development of Lubricants for Shell Drawing.*—In the production of brass shell cases, sheet metal is pressed by a series of steel dies until the final shape is achieved. For this process specialized lubrication is necessary to prevent seizure of the brass on the die, particularly if the number of drawing operations is reduced. In collaboration with industrial laboratories, different types of lubricants were tested, and as a result locally produced lubricants were developed which were more effective than the soaps in current use. Some of these compounds produce staining of the brass surface, and further work into the detailed action of these compounds is being carried out.

Experiments have also been carried out to determine the efficacy of thin metallic films as lubricants in the deep drawing of steel, earlier work having shown that thin metallic films may, under appropriate conditions, be very effective as extreme pressure lubricants (see below).

(v) *Extreme Pressure Lubricants.*—When the load between moving surfaces is very large and high temperatures are developed, it is customary to add to the mineral-oil, compounds containing sulphur, chlorine, or phosphorus or other active ingredients which may attack the surfaces chemically and form a protective film which reduces the extent of metallic seizure. An investigation of the mechanism of extreme pressure lubrication is being carried out, and work is being done on the development of more efficient extreme pressure lubricants. Experiments on organic compounds containing sulphur and other active groups have shown that the behaviour of these compounds is very specific and depends on the reactivity of the sulphur and the other active groups. This work is at present in the initial stages. However, certain sulphur and chlorine compounds which have been investigated show remarkable E.P. lubricating properties at high temperatures. These investigations are being extended to compounds of phosphorus, chlorine, and other active organic compounds.

(vi) *Cutting Fluids.*—Apart from their properties as coolants, cutting fluids serve the fundamental purpose of preventing seizure and excessive wear between the tool and the work, under the conditions of high load and temperature developed during the machining operation. In conjunction with others, investigations were made of the lubricating properties of various oils under conditions of heavy loads and high temperatures. Using these results as a basis, certain cutting oils have been developed and are being widely used. In collaboration with the Lubrication Sub-committee of the Munitions Supply Laboratories, a series of tests has also been carried out on the lubricating properties of various commercial lubricants in order to grade them for specific types of work. This has been of value in selecting cutting, grinding, and honing oils for various industrial operations.

(vii) *Reclamation of Lubricating Oils.*—Since all the lubricating oil used in Australia must be imported, its economy is a matter of some importance. Work has been carried out on the analysis of used and reclaimed oils and on the efficacy of various methods of treatment.

(viii) *Examination of Lubricating Oils.*—Chemical analyses and physical tests have been carried out on a variety of oils submitted by the fighting Services and others, and the influence of various addition agents has been studied.

3. The Development and Manufacture of Aircraft and Other Bearings.

The general work on the development and manufacture of aircraft and other bearings has been continued. The work falls into two main parts. The first is a more basic investigation of the properties of bearing alloys and a study of the causes responsible for changes in structure, the development of defects in manufacture, or failures in service. The second is the development of techniques for the manufacture of the major aircraft bearings. There has been a considerable expansion in this work, and it has been extended to a number of new bearings. Electrolytic deposition as well as stationary and rotary casting methods have been developed and the technique handed on to the Services and to manufacturers. The work is done in association with the Pilot Bearing Annexe of the Department of Aircraft Production, and general application of the work comes under the Bearing Control Committee.

(i) *Structure of Bearing Alloys.*—A study is being made of the structure of different classes of bearing alloys and the influence of composition, casting temperature, atmosphere, and rate of quenching on porosity, segregation, cracking, and bond strength.

(ii) *Bearing Testing.* — Investigations are being made of the performance of ball bearings and other bearings under certain defined conditions of operation, and of the factors responsible for seizure and breakdown.

(iii) *Thermal Fatigue.*—Apparatus has been constructed for the investigation of thermal fatigue, and this is being used to investigate the properties of a number of metals and bearing alloys which are subjected to fluctuating temperatures.

4. Friction and Wear.

Investigations are being continued into the physical processes that occur during the wear of metals and other materials under various experimental conditions. For this purpose special apparatus has been developed to measure the wear and friction between sliding surfaces.

(i) *Theory of Bearing Alloys.*—Earlier work has shown that the frictional resistance between sliding surfaces is due primarily to the shearing of metallic junctions formed at the points of contact and to the force required to drag or plough the surface irregularities of the harder metal through the softer one. This theory has been placed on a more quantitative basis, and it has been found possible to evaluate separately the ploughing and shearing factors in terms of the physical properties of the materials. In general the friction is determined by the real area of contact and the shear strength of the softer material.

It is not, as a rule, possible to decrease the friction by using a metal of low shear strength, since such a metal is usually soft and gives a comparatively large area of contact. For this reason most clean metals give a high coefficient of friction, of the order of $\mu = 1$. The earlier work showed, however, that a small value of shear strength and area of contact may be achieved by depositing a thin film of a soft metal on a hard one. The hard surface supports the load, giving a small area of contact, whilst the shearing takes places within the thin film of the softer metal (low shear strength). Under these conditions it is possible to obtain extremely low coefficients of friction, comparable with that observed on ice.

The behaviour of thin metallic films has been applied to an investigation of the theory of action of various types of bearing alloys. For those alloys which consist of a hard metal with a softer metal finely dispersed through it (*e.g.*, copper-lead alloys), the frictional behaviour resembles very closely that of a hard surface consisting of the matrix material, over which a thin film of the softer metal has been spread. The experiments show that for this type of alloy the extrusion and smearing of a thin film of a soft constituent over a harder matrix determines the intrinsic frictional and wear reducing properties of the alloy. For "white-metal" bearing alloys which consist of a soft matrix in which are embedded a number of hard crystals, experiments show that the frictional properties may be determined essentially by the properties of the softer matrix. Apart from their theoretical interest, these results have important applications in the development and manufacture of bearing alloys.

(ii) *Mechanism of Wear and Influence of Dust Particles.*—Basic work has been continued on the wear of metal surfaces. Considerable light has been shed on the mechanism of wear and metallic friction by an examination of the contours of the worn surfaces, using taper sections. In this technique a section is cut at a very oblique angle to the worn surface giving a contour of the surface with its vertical component magnified about ten times. These and other observations show that a minute local welding of the surface occurs during sliding. In some cases wear proceeds by the plucking of these minute portions of the metal out of one of the surfaces; in other cases it proceeds by a more direct abrasive action.

This work has been extended to an investigation of the effect of the size, shape, composition, and concentration of dust particles on the wear of metal surfaces.

(iii) *The Reduction of Wear by Chromium Plating.*—Previous work has shown that the wear of metal surfaces may be considerably reduced by plating the surfaces with a thin film of a hard wear-resisting metal, such as rhodium or chromium. For this film to be effective, experiments have also shown that it must exceed a certain thickness. Chromium plating is used on the cylinders and piston rings of internal combustion engines, and it is therefore important to determine the effect of high temperatures on the wear properties of these films. Experiments carried out at room temperature and at 240° C. show that the friction is only slightly increased at high temperatures and that the wear of the chromium film may be as low as, or even lower than, that observed with cold surfaces. In collaboration with the Munitions Supply Laboratories, investigations have also been carried out to determine the plating conditions within which wear resisting films may be deposited, and to correlate these properties with the structure of the chromium. This work is still proceeding.

(iv) *Wear of Aircraft Cylinders.* — Previous investigations have revealed the fundamental differences in the basic wear properties of different steels used for cylinder barrels, and have shown that certain defects in the steel are associated with heavier wear. It is clear, however, that in practice wear is also largely influenced by the conditions under which the engine is operated. Experiments have shown that in the presence of small quantities of very fine abrasive particles, such as may easily pass through standard filters into the engine, the wear rises very markedly, and an increased probability of seizure may ensue. This work is being continued.

(v) *Wear of Brake Materials.* — Investigations have been carried out on the wear of brake materials.

It has been shown that the wear depends very markedly on the surface finish of the brake drum. It has also been found that the presence of small quantities of water or small quantities of typical dust may cause a great increase in wear for many types of brake materials. The effect of temperature on the friction and wear has also been investigated in certain cases. This work has been of value to the Services in enabling them to select locally-produced brake materials for various types of vehicles.

(vi) *Friction and Wear Properties of Plastic Bearing Materials.* — Various plastics have been examined to determine their suitability as bearing materials. Investigations have been carried out on their friction and wear properties, at room temperature and at elevated temperatures, in the presence and in the absence of oil or water. These experiments have been used to select local products which possess suitable properties.

5. The Study of Transient Phenomena.

Electrical methods have been developed for investigating events which happen in a very short interval of time (of the order of microseconds) and the method and apparatus is being applied to the study of transient phenomena associated with friction and impact, and to explosive reactions.

6. Miscellaneous.

Assistance and advice has been given to the Services, to the Department of Aircraft Production, to Government organizations, and to industry on a variety of problems, and short investigations have been made on problems such as the development and casting of alloys for gear pumps, the examination of adsorbent powders for oil reclamation, anti-corrosion greases for bearing and engine parts, causes of contamination and frothing in turbine oil. Members of the Section are acting on or are assisting, various committees such as the Bearing Control Committee, the Aeronautical Research Committee, Lubrication Sub-committee (Munitions Supply Laboratories), and the Standards Association.

XIV. OTHER INVESTIGATIONS.

1. Dairy Research.

(i) *General.*—The work of the Section during the year has been confined to problems arising because of war conditions. Close collaboration has been maintained with the Services and Government Departments, particularly through the Scientific Advisory Committee (Foodstuffs) of the Australian Food Council. Apart from laboratory investigations, much time has been spent on developing several new products on a commercial scale. Numerous members of the Australian dairy industry have whole-heartedly co-operated in such work.

(ii) *Tinned Butter.*—Work on the keeping quality of tinned butter which was mentioned in the last report was continued. A good measure of control over bacterial development was obtained by the proper incorporation of 3 per cent. of salt or 2.5 per cent. of salt together with 0.25 per cent. of boric acid. Unfortunately, such control brought into strong emphasis tallowy flavours due to fat oxidation. The following methods have been tried and found to be without significant effect in controlling the fault, (1) reduction of air content of butter to as low as 0.1 per cent. by volume by working the butter in a vacuum, (2) tinning under vacuum, (3) incorporation of strongly heated milk in butter (there were some indications that this might act as an antioxidant), (4) pasteurization of cream at a temperature of 10° C. in excess of normal, (5) non-washing of butter resulting in a higher curd content. Some measure of control was obtained by the use of certain chemical anti-oxidants, but, from other points of view, the desirability of the use of these is questionable. In any case if the tinned butter were exposed to sufficiently high temperatures to melt, its deterioration was rapid. As much tinned butter is required for such conditions, attention was concentrated on the preparation of a substitute which would not suffer from the disabilities of butter.

(iii) *Hardened Butter Substitutes.*—A systematic investigation of the influence of several harder fats on the melting point of dry butterfat has been made with the object of increasing the melting point above tropical temperatures. It was decided, as a compromise between high melting point and palatability, that the most desirable mixture should have a melting point of about 105–110° F. Experiments showed, that with correct methods of cooling, such a fat had a texture not unlike butter at room temperatures and was smooth and palatable. A small proportion of salt improved the flavour, but hastened deterioration caused by oxidation of the fat. Skim milk powder, by acting as an antioxidant, was found to overcome this difficulty. Removal of air during manufacture also reduced the risk of oxidation. Because the mixture contains no water it is not subject to bacterial deterioration. For several reasons hydrogenated butterfat was chosen as the hardened fat for the product. This product, which has been named "tropical butterfat spread," consists of a mixture of dry butterfat, hydrogenated butterfat, salt, and skim milk powder. After considerable laboratory work on its properties, tropical butterfat spread is now being manufactured on the large scale.

Experimental work has been done on other suggested butter substitutes which use butter or butterfat as a basis, in order that information might be given on their properties and manufacture should they be required.

(iv) *Dry Butterfat.*—The commercial manufacture of dry butterfat from butter is now being conducted on a large scale in Australia, both for the purpose of obtaining a good grade of butterfat from low grade butters, and for preparing the raw material for the manufacture of tropical butterfat spread. Experimental work on the properties and commercial preparation of dry butterfat has been continued. In collaboration with Department of Commerce officers, the quality of fat produced from butters suffering from various forms of deterioration has been determined. As would be expected, if the fault in the butter is associated with the non-fatty portion of the butter, the resultant fat can be of good grade. It was found that by suitable treatment a satisfactory fat could be prepared from tinned butter which had been held under extreme temperature conditions, was over a year old, and quite unfit for use as butter, even for cooking purposes. Considerable work has been done on factors influencing the oxidation of the dry fat, the principal cause of deterioration. The effects of iron, copper, moisture, air, salt, skim milk powder and various antioxidants on the oxidation have been investigated. The stability of emulsions of butterfat and serum which are sometimes formed when the butter is melted have been studied, as it influences the efficiency of the centrifuges in separating the fat. The centrifuges cannot reduce the moisture content of the fat below that of the solubility of water in butterfat, and in this connexion various methods for determining moisture of the order of 0.1% in butterfat have been compared and the solubility of water in butterfat has been determined. The fat is at present exported in 4-gallon tinplate containers. These have

not proved completely satisfactory, and experiments are being conducted on the use of black iron drums. Very favourable reports have been received on the first trial shipment in these drums; controls held in Australia were satisfactory.

(v) *Cheese.*—Leakage of fat is one of the main factors restricting the use and transport of cheese at high temperatures. A study of the influence of certain variables on the extent of fat loss was made during the year. Organic stabilisers (pectin and agar) had little effect on the fat loss. They caused some deterioration of flavour and increased the amount of fat carried off in the whey. Reduction of the fat content of the cheese greatly reduced the leakage of fat at high temperatures, and the minimum fat content compatible with satisfactory texture was studied. While this work was in progress, a more promising method involving homogenisation of the fat globules was independently developed in Queensland by officers of the State Department of Agriculture, and the Queensland Butter Board. Tests conducted by this Section have confirmed the great improvement in fat stability brought about by the process.

(vi) *Compressed Milk Powder.*—(*a*) *Storage Tests On 1.25-Pound Blocks of Compressed Whole Milk Powder.*—A series of storage tests on 1.25-lb. blocks of compressed whole milk was completed during the year. The blocks were compressed at 10,000 lb. per sq. in. and were wrapped in cellophane, waxed paper, and a combination of these two wrappings. Blocks stored at 37° C. were slightly stale after 12 weeks, and stale at 18 weeks. At 30° C. and 75–80% relative humidity, the insides of the blocks became slightly stale after 3 months' storage, but at 9 months showed no further deterioration. The outsides of the blocks deteriorated progressively, and at 9 months were very stale. At room temperature and humidity, slight staleness developed at 3 months in the inside of the blocks, but as with the 30° samples no further deterioration occurred up to 12 months. The outside samples showed progressive deterioration and were very stale at 12 months. In general, fat oxidation was rare in the stored blocks and "protein staleness" apparently accounted for most of the deterioration. A report from the Hannah Dairy Research Institute, Scotland, on the quality of compressed whole milk blocks sent to Great Britain as a trial shipment, was encouraging. The blocks were examined 6 months after manufacture, and the repowdered milk found to be completely soluble. The flavour of the interior of the blocks was but slightly inferior to that of freshly prepared powder, but the outside was perceptibly stale.

(*b*) *Compressed Sugar and Milk.*—As mentioned in last year's report, blocks made by compressing a mixture of 80% whole milk powder and 20% ordinary sugar are readily crushed by hand and the resulting material is easily dissolved. As the chief disadvantage of the straight milk blocks was the difficulty of repowdering, the sugar-containing blocks were of interest to the Services and have been tried for various purposes. Slabs weighing 1 oz. made by sawing large blocks were used for a time in Army operational packs, but at the high temperatures to which they were sometimes subjected, over 120° F., they rapidly deteriorated. A number of 1-lb. blocks were prepared for the Navy, and after storage in Melbourne for 6 months and then 2 months in the tropics, were finally returned to Melbourne for examination, 12 months after manufacture. Deterioration was no more than barely detectable, and as a result of this experiment a more extensive trial is being made.

In laboratory storage experiments with 1-oz. slabs of compressed whole milk, milk with 20% sugar, and milk flavoured with vanilla, it was noted that both the sugar and vanilla delayed the appearance of staleness. For example, plain milk slabs stored in tins at 37.8° C. were stale after 68 days, whereas slabs containing either sugar or vanilla were graded as very slightly stale. Not until 140 days, were the slabs containing sugar or vanilla classed as stale. At 29° C. the useful life of slabs containing either vanilla or sugar is over 165 days (experiment not yet completed), while at 49° C. the slabs were unusable after 28 days.

(*c*) *Keeping Quality of Skim Milk Powder.*—As whole milk powder will not stand a storage temperature of 120° F. a preliminary experiment with skim milk powder was made. At 120° F. it rapidly deteriorated, and at 6 weeks was very stale and slightly brown. As a result of storage experiments with whole and skim milk powders, it has been concluded that at high temperatures protein staleness is at least as important as oxidative rancidity in limiting the life of these products, and an investigation of staleness has been started.

(vii) *Lactic Acid from Whey.*—Australian production of lactic acid has increased considerably owing to the difficulty of importing the acid and its increasing use in industry. The acid is being manufactured from whey, but difficulties have occurred owing to slow and erratic fermentation. Some work has been done on this problem. Preliminary results indicate that, as would be expected, various strains of lactobacilli vary greatly in their capacities to ferment the lactose in whey, and promising results have been obtained by the use of mixed cultures. The quality of the whey and the heat treatment to which it is subjected also influence the rate of fermentation.

2. Radio Research Board.

During the year, the work of this Board has been mainly centred in laboratory space made available in the Electrical Engineering School of the University of Sydney. Following a conference of the fighting Services and others that was held in Sydney in September, 1942, there has been a considerable increase in the volume and scope of the programme of the Board's work. The results of this work are proving of considerable practical value to the Services, but for security reasons no details can be given. The University of Queensland is now affording helpful co-operation in the running of a field station established in Brisbane. The Mt. Stromlo Observatory, the Watheroo Observatory, and the Melbourne Observatory have also continued to give valuable assistance.

3. Mineragraphic Investigations.

Forty-one investigations have been carried out into the mineral association of rocks, ores, and mill products submitted by mining companies and institutions, and the majority have contributed to the search and production of metals required for war purposes. Each investigation was complete in itself and was directed to some specific problem mostly connected with the occurrence of a valuable mineral in an ore, concentrate, or tailing. Twelve investigations were concerned with ores that were subjected to experimental treatment in the ore-dressing laboratories, while six dealt with materials under investigation by the Minerals Committee at Canberra.

One of the latter included a petrological examination of a series of rocks from the scheelite mine at King Island. It was found that the scheelite occurs chiefly in a garnet-hornfels and to a less extent in a garnet-diopside-hornfels. As these rocks are derived by the contact metamorphism of a calcareous sediment and are extensive and interbedded with other types of hornfels, an environment exists for an occurrence of scheelite of considerable magnitude.

An extensive examination was made of the composition of the tin-bearing veins of Renison Bell, where the tin occurs chiefly as cassiterite and, to a minor degree, as stannite, in a gangue consisting largely of iron sulphides. The nature and character of the losses that are involved in milling these ores were determined in a comprehensive examination of the varying concentrates and tailings produced in successive stages in the operating mill. A similar suite of minerals was found in tin ore from the North Valley lode at Mt. Bischoff, where the cassiterite crystals have a somewhat larger grain size. This similarity included even the occurrence of occasional minute particles of native bismuth.

The investigations have been facilitated by contributions from a number of mining companies through the Australasian Institute of Mining and Metallurgy. The University of Melbourne has also assisted by granting laboratory accommodation in the Geology School.

4. Ore-Dressing Investigations.

Co-operative investigations have been continued in the laboratories at the Kalgoorlie School of Mines, the South Australian School of Mines and Industries, and the Metallurgical School of the University of Melbourne. As in the previous year, conditions arising out of the war continued to emphasize the importance of minerals other than gold.

At Kalgoorlie, where considerable attention has been paid to investigations into the treatment of base metal and non-metallic strategic minerals, the principal investigations have been the concentration of graphite ores from Munglinup, flotation concentration of pyritic ore from Norseman for utilization in the manufacture of sulphuric acid, recovery of scheelite from ores from Higginsville and Comet Vale and of scheelite and wolfram from accumulated and current mill tailings from Edna May Amalgamated Gold Mines at Westonia. The last named investigation has provided the metallurgical information necessary for the design of a suitable recovery plant which is now being erected. An investigation was also conducted into the treatment of a pyritic gold-copper ore from Widgemooltha for the purpose of recovering both gold and copper and of producing a high grade pyrite concentrate suitable for use in the production of sulphuric acid. In addition, the possibility of recovering rutile, zircon, and ilmenite from beach sands on the south coast of Western Australia has been investigated, and a small water-jacketed copper smelting furnace has been erected at Ravensthorpe to produce blister copper from the oxidized ores of that district. Problems of gold ore treatment have also been investigated, but these have formed only a minor portion of the work of the Laboratory, which has been for the most part devoted to the recovery of strategic minerals required for war purposes.

At Adelaide, work has been continued on graphite, particularly in assisting the production company with technical criticism and advice. An investigation is in progress on the preparation of high-grade fluorite to be used in the manufacture of aluminium. Special attention has been given to local deposits of phosphate which in peace-time were too low-grade to be able to compete with the imported rock. Three reports have been issued and work is still in progress.

At Melbourne, the major investigation for the period has been the work leading to the design of the King Island Scheelite Company's new large tungsten concentrator. This investigation, which has been carried out at the request of the Controller of Minerals Production, has occupied the greater part of the laboratory's time. The work has been very detailed and is unique in the respect that final plant design for each treatment stage has been determined in detail as the direct result of laboratory findings without any intermediate pilot plant work. At the commencement of the work the ore characteristics were completely unknown. All the remaining work has been on base metal ores, those of copper, antimony, tin, and tungsten receiving most attention. During the year close liaison has been established with the Controller of Minerals Production and the Mineral Resources Survey; both of these organizations have kept the laboratory well supplied with work.

5. Biometrics.

(i) *General.*—Under the system of re-organization established early in 1941, the Section has continued to be actively engaged in co-operation with officers of the Council's Divisions, and also with various external organizations. The confidential investigations undertaken on behalf of the latter, *viz.*, various branches of the Services, and other bodies directly or indirectly associated with the war effort, comprised a large part of the work done during the period under review, and are reported elsewhere. To meet the increased demands of the work, further additions were made to the staff and calculating equipment. During the year one officer remained seconded—at first to the Department of Home Security and later to the Directorate of Manpower.

(ii) *Division of Plant Industry.*—Statistical assistance has been given to the Pathology Section in connexion with a yield trial of garden peas infected with mosaic virus, a yield and disease rating trial of maize grown on soils prepared with different green manures and fertilizers, and an experiment on the response of *P. radiata* in the Wingello and Penrose districts to superphosphate. Other work included the analysis of a pot experiment designed to provide evidence on the association of take-all of wheat with minerals in the soil, and also the design of a field trial with fertilizers applied to an area with a very high percentage of take-all the previous season.

For the Agrostology Section, considerable time has been spent in maintaining the tabulation of data for two long-term grazing trials, one on a sown pasture at Canberra, and the other on a Mitchell grass pasture at "Gilruth Plains." Assistance was given in the analysis of field and pot manurial trials with lucerne and in the analysis of a series of spraying trials for the control of hoary cress.

Other work for the Division included the design of a vernalization experiment for cabbages, a progeny trial for subterranean clover, and a series of pure line and pasture mixture trials of recent introductions. The analyses of variety and rate of sowing trials with flax were also made.

(iii) *Division of Economic Entomology.* — The work for this Division during the year included analyses of field spraying trials made against Rutherglen bug, potato moth, cabbage butterfly, and aphids; analyses for a series of experiments on dusting of potato tubers against larvae of potato moth; the design and analysis of spray trials for house flies and mosquitoes and trials with spreading oils for mosquito larvae; preliminary designs for gauging the colour preferences of house flies; and the estimation of weevil populations by sampling.

(iv) *Division of Forest Products.* — During the period under review, the Section has continued with the planning of investigations and the analysis of experimental data for the several Sections of this Division.

For the Timber Mechanics Section analyses have been made to determine working stresses for a variety of timbers and the correlations of various

properties of plywood from different species. For the Chemistry Section a number of experiments relating to the manufacture and testing of paper pulp have been analysed; these include Lampen mill studies, comparison of Lampen mill and Kollergang, stock divider and stock press studies, burst tester and tear tester studies. For the Flax Section work done included analyses of retting experiments from agricultural trials, comparisons of retting methods, and studies of strength testing methods. Other work included the analysis of experiments on the effect of high and low temperatures on the mechanical properties of solid timber, plywood and strength of glue line (Timber Physics Section), and studies of testing technique, manufacturing technique, comparisons of resins as adhesives, and the examination of commercial test results with a view to framing specifications (Improved Wood Studies). A great amount of external advisory work has also been undertaken, particularly for paper companies in connexion with the institution of quality control technique in manufacturing plants.

Routine computations included the calculation of specification tests on aircraft timbers (53,000), moisture contents (80,000), miscellaneous tests (17,000), and the calculation of means, standard deviations, and standard errors of means for mechanical and shrinkage properties and density of timber, for different species.

(v) *Division of Animal Health and Nutrition.*—The Section has continued with the extensive study of data derived from the parasitological field trials at Armidale (N.S.W.). Throughout the past year the work consisted principally of the reduction of primary climatological data in order to correlate them with the variations in worm burden. Other work in parasitology included the analysis of data from field trials at Gostwyck, Cherry Hill, Moredun, Canberra, and Hillcrest, which had been designed to determine the efficacy of various anthelmintics. The remaining major contributions to the year's work consisted of the analysis of an extensive set of data derived from progeny testing trials and further investigations on the development of a technique for estimating the numbers of eggs of parasitic worms in faecal material.

(vi) *Irrigation Research Station, Griffith.*—In the last report it was stated that the analysis of the data from the Griffith Horticultural Survey had been completed and that the Section was collaborating with officers of this Station in preparing a report on the investigation. This report was completed early in the period under review, and a description of the investigation and summary of the results are being published as Bulletin 168.

(vii) *National Standards Laboratory.*—The Section completed an extensive set of tables which were designed to facilitate the reduction of observational data obtained with certain optical equipment in the Physics Section of this laboratory.

6. Standards Association of Australia.*

The Association's activities in the preparation of standards related to defence needs have been fully maintained during the past year. The total number of Australian standards now exceeds 600, of which over 200 are war-time Emergency Standards. A large proportion of these furnish the basis for controlling the quality of aircraft materials and components. Others are related to munitions of various types, home defence needs, A.R.P. requirements, substitute materials to replace others in short supply, and the like. Some valuable reports furnish data which give guidance to aircraft servicing authorities, designers, and others in regard to the interchangeability of components and materials.

The Association has continued to give service in respect of the supplying of Australian reprints of overseas standards under authority from the respective original publishers. In addition to British Standard and British Air Ministry Specifications, these include standards of the American Standards Association and the Society of Automotive Engineers (Inc.) of U.S.A. Many hundreds of such documents have been reprinted to meet Governmental needs.

The Association's information service in relation to specifications continues to be in strong demand, and has an established position in the eyes of departments of government and in industry and commerce.

XV. INFORMATION SECTION.

1. General.

The demand for the services of the Information Section by industrialists, business organizations and their scientific investigators, Government departments, and by the Council's own staff, reported in previous years, has continued. Apart from its normal functioning as a centre for the dissemination of scientific information, the Section is making a distinct contribution to the war effort, especially in the preparation of summaries and bibliographies in connexion with aspects of technical production, in the compilation of information on the substitution of Australian raw materials for materials formerly imported, and in the preparation of information on ways and means for extending the useful life of further articles and materials in short supply.

2. Information for Council.

During the year, a considerable amount of work has been carried out for the Executive Committee and the various Divisions of the Council. For example, in connexion with the programme to establish rubber-producing plants in Australia, a report was prepared on the conditions considered necessary for the growing of guayule in California; in the light of that experience areas in Australia were defined wherein successful cultivation might be expected. Surveys were also made into the uses of citric acid in foodstuffs and of the amounts considered essential in the various industries associated therewith, and into the utilization of phosphates in foods. Consideration was given to the replacement of citric acid by acid phosphates or by other possible substitutes. Other matters reported on concerned oils and waxes and methods of extraction and possible utilization of flax wax.

To give assistance in the investigational work eventually to be carried out by the Council's Divisions, using the electron microscope, an extensive bibliography was prepared on the construction and performance and general application of the instrument. In addition, a paper was presented to the Australian Chemical Institute summarizing its various fields of application and the value of the instrument in research projects.

Once again, the Division of Industrial Chemistry has used the Section in the initial stages of certain of its projects. In connexion with the investigations relating to the conservation of tin supplies, a report was prepared on the relative efficiencies of hydrogen and carbon monoxide in the gaseous reduction of cassiterite. A further summary relating to tin conservation was also prepared on fluxes for low tin solders. Other matters looked into related to the

* This Association is an independent body which is financially supported by contributions from Governments and industries. The Council for Scientific and Industrial Research acts as the liaison body between the Association and its main contributor—the Commonwealth Government.

possible chemical removal of carbon deposits from internal combustion engines, the simultaneous production of iron and cement, the production of bitumen from shale, and the melting of metals in vacuo.

A detailed literature survey was also made for the purpose of obtaining information on the manufacture of styrene, required for the preparation of resins and synthetic rubber, and of its polymerization. The literature on the preparation and properties of secondary alcohols and ketones of high molecular weight (obtained from fatty acids) has also been reviewed in the light of their possible value as substitute materials for waxes.

Assistance for other Divisions has covered the manufacture of ball bearings, balls and ball races, the cutting of diamonds, the manufacture of diamond dies, the electro-pickling of steel, and notch sensitivity and the testing of bearings.

Extensive bibliographies have been compiled on the storage of vegetables, on the drying of vegetables and on the greaseproofing and waterproofing of paper and similar packaging materials.

3. Information for Manufacturers, Government Departments, &c.

The usual demand from Government departments, manufacturers, and private individuals, in addition to the above-mentioned demands from within the Council, has been experienced. In this field of its activities the Section does not confine its activities to literature surveys; it also plays an important part in putting enquirers into touch with authorities or laboratories—many of them quite outside the Council—concerned with the subjects at issue. Some of the most important requests have been concerned either with the conservation of materials or with the preparation or utilization of substitutes for materials in increasingly short supply.

Conservation of Materials.—A comprehensive summary of available information on methods for the extension of the wearing life of clothing, footwear, &c., was prepared for the Rationing Commission. This report was considered of great value to the Commission and later formed part of a more comprehensive summary prepared on the care and preservation of household goods of all types for the Department of War Organization of Industry. Reports were also prepared on methods for the prevention of the deterioration of ground sheets and parachute silk, the effects of dry cleaning processes on various textiles, the fireproofing of textiles, the facing of maps to ensure longer useful life, the use of alkalies in soaps, substitution of salt cake for soda ash in glass manufacture, low-tin solders, and possible substitutes for linseed oil.

A selection of other matters concerning which requests have been received is as follows:—*Preparation of chemicals*: Formic and oxalic acid from carbon monoxide, 8-hydroxyquinoline, silica aerogel, dithio-salicylic acid, o-sulphobenzoic acid, hydroquinone, metol, amidol, chloroform, lecithin from egg yolk, acetaldehyde from acetylene, lactic acid, bromal, bromethol, electrolytic production of hydrogen, urea, citric acid, tartaric acid, cream of tartar, penicillin, gramicidin, artificial graphite, carbon black, magnesium trisilicate. *Foundry and engineering problems*: Graphite crucibles, surface tension of molten metals, Detroit rocking arc furnace, heat treatment of alloys, cutting and quenching oils, extrusion of metals, indium-silver alloys, indium plating, hard chromium plating, electrolytic production of copper and iron tubes, wetting agents for nickel plating baths, liquid air machine for oxygen production, colouring zinc alloys, etching aluminium, ultrasonics, refrigerating brine, casting manganese bronze, uses of electrolytic manganese, electrolytic polishing of stainless steel, anodizing aluminium, hard nickel plating. *Food problems*: Dehydration of fruit, vegetables, meat, butter and eggs, meat extracts, sugar beet, apple treacle, gelatine, olive oil, carrot juice, flavouring essences. *Fuels*: Coal dust for I.C. engines, alcohol petrol blends, use of wet alcohol, production of gaseous hydrogen as a fuel, petrol pump diaphragms. *Utilization of waste products*: Recovery of wool grease, wood distillation, glue from hides, utilization of bracken, by-products from abattoirs, distillation of bones, flax wax. *Storage batteries*: Cadmium-nickel and zinc-lead storage batteries, synthetic resins for battery containers. *Miscellaneous*: Ships' paint, perspex, soybean protein, tanning sheepskins, bonding materials for diatomite, "immunizing" cotton, vulcanized red fibre, fluorescent printing inks, sunflower oil, scent production, rapeseed cake, synthetic rubber, whale oil, use of carbon dioxide in blasting cartridges, effect of colour on flies, lead poisoning, specifications for chromite ores, wool as an insulating agent, rotenone from Lonchocarpus, lucerne meal for animal feeding, gas bags for automobiles, growing tea, angora rabbits.

4. Committees, Abstracts, &c.

Officers of the Section have continued to act on various special committees; for instance, one has acted as Chairman of the Standards Association Committee on the Rotproofing of Materials. During the year, it was recognized that it would be of mutual benefit to certain of the Council's Divisions and Sections and to the Munitions Supply Laboratories if closer liaison were maintained between the two organizations and each were regularly informed of the projects and investigations being carried out by the other. To this end a definite contact was established and an officer of the Section appointed to act as the Council's liaison officer; he also acts in a similar capacity in maintaining contact with the Department of War Organization of Industry and the Commonwealth Scientific Liaison Bureau.

Officers of the Section have continued to act as an abstracting panel for the preparation of the "Australian Chemical Abstracts" which are confined entirely to reports and articles published in Australia and to Australian patents, and which are published by the Australian Chemical Institute.

5. Library.

The Council's Library has continued to develop, particularly on the industrial side. The recognition of its value is emphasized by the increasing use outside organizations and individuals are making of it. While the same difficulties are being experienced as in previous war years, in the obtaining of references from overseas publications, the further development of the photographic microfilm service during the year has off-set this trouble to some extent. The subject indexing of the library is being completely revised and re-organized on the sound principles as laid out for the alphabetico-classed system.

Efforts to record library holdings of journals throughout Australia not mentioned in the Catalogue of Scientific and Technical Periodicals in libraries in Australia, have been continued, and the function of the Council's library to be considered by other libraries as a central bureau of information on scientific periodicals is being developed. In connexion with this plan a comprehensive survey of the abstracting and indexing periodicals in the Council's library was made during the year. In the summary prepared therefrom, information is given as to the purely indexing or abstracting nature of the particular periodical, the field covered, the extent to

which the literature of that field is covered, the frequency of publication, the publishing body, the historical record of the publication in order to ensure a continuity of coverage from initial publication to the present, the period over which the periodical has been taken by the library, and, where such publication has not been taken from its inception by other libraries in Melbourne or attached to various of the Council's Divisions, where earlier volumes may be obtained.

The recognition of the necessity for specialized libraries throughout the new departments dealing with war activities has led to the building up of small libraries of current periodicals and essential text-books by these organizations. In addition, the establishment of technical libraries by other public and semi-public bodies and private firms is continuing. As a result the call on the library staff for advice and assistance in regard to their organization and maintenance has increased materially during the year. When this factor is considered in conjunction with the difficulties experienced by the Council in obtaining the services of trained personnel for its own libraries, the urgent necessity for the provision of facilities for the adequate training of librarians in Australia cannot be too strongly emphasized.

6. Photographic Copying.

The great value of the small sized camera in disseminating information has been further demonstrated by experience during the past year. Scientific workers in Government and University laboratories and in industry continue in still increasing numbers to use the Section to obtain copies of scientific articles or reports otherwise inaccessible to them. This service is proving of particular value in overcoming difficulties caused by the war's interruption of the distribution of many technical journals that formerly reached Australia. In addition many libraries and organizations continue to give most helpful co-operation by lending the Council their special literature for photographing, and in this way are helping to weld the scattered scientific information available in different Australian localities into the one national whole.

The microfilm camera is also proving of considerable value to the Council's liaison offices that have been established in England and America. By its use a very considerable volume of unprinted reports —many of a secret or confidential nature—are regularly being transferred to Australia. The Section is looking after the distribution of this information.

XVI. FINANCIAL MATTERS, STAFF, AND PUBLICATIONS.

1. Finance.

The statement of expenditure from 1st July, 1942, to 30th June, 1943, is as follows:—

	£	£	£
1. Salaries and contingencies			46,612*
2. Remuneration of Chairman and Members of Council			2,577†
3. Investigations—			
(i) Animal Health and Nutrition Problems		64,309	
Less contributions from—			
Commonwealth Bank	5,500		
Department of Agriculture and Stock, Brisbane	1,000		
George Aitken Pastoral Research Trust	2,000		
University of Sydney	250		
Australian Cattle Research Association	3,000		
Australian Wool Board	7,598		
Australian Meat Board	135		
Revenue Funds—			
Vaccine	1,349		
Pleuro Pneumonia	791		
Mastitis	1,136		
Toxaemic Jaundice—Barooga	117		
F. D. McMaster Field Station	300		
"Gilruth Plains" National Field Station	3,542		
Nutrition Laboratory	255		
Oestrus Experiment	39		
		27,012	
			37,297
(ii) Plant Problems—Division of Plant Industry		44,462	
Less contributions from—			
Australian Wool Board	1,500		
Department of Supply and Shipping	2,000		
Department of Commerce	1,850		
		5,350	
			39,112
(iii) Entomological Problems—Division of Economic Entomology		16,234	
Less contributions from—			
Ministry of Agriculture, Egypt	79		
Australian Wheat Board	856		
Central Wool Committee	387		
Commonwealth Bank	19		
		1,341	
			14,893
(iv) Horticultural Problems of the Irrigation Settlements—			
(*a*) Citricultural—Research Station, Griffith	11,008		
Less contributions	3,792		
From—		7,216	
New South Wales Water Conservation Irrigation Commission	2,000		
Griffith Research Station Revenue Fund	1,784		
Murrumbidgee Irrigation Area Co-operative Society	8		

* The main items of expenditure under this heading are salaries of the Administrative staff at the Council's Head Office; salaries and expenses of officers at Australia House, London, and at Legation, Washington; staff and upkeep of State Committees; travelling expenses of Head Office staff, members of the Council, &c., and printing and general office expenditure.

† Provided from Consolidated Revenue Fund.

	£	£	£
(*b*) Viticultural—Research Station Merbein	6,813	..	..
Less contributions From—	3,762	..	..
		3,051	..
			10,267
Dried Fruits Control Board	701	..	..
Irymple Packing Proprietary Limited	248	..	..
Mildura Co-operative Fruit Company	248	..	..
Red Cliffs Co-operative Fruit Company	248	..	..
Aurora Packing Proprietary Limited	248	..	..
Nyah Woorinen Enquiry Committee	12	..	..
Department of Supply and Shipping	216	..	..
Merbein Research Station Revenue Fund	1,841	..	..
(v) Soil Problems	..	7,282	..
Less contributions from—			
Commonwealth Bank	1,500	..	..
Australian Cement Manufacturers Association	314	..	..
		1,814	..
			5,468
(vi) Food Preservation and Transport Problems—	..	27,283	..
Less contributions from—			
Commonwealth Bank	4,500	..	..
New South Wales Department of Agriculture	800	..	..
Queensland Meat Industry Board	850	..	..
Australian Meat Board	500	..	..
Metropolitan Meat Industry Commission	500	..	..
Egg Producers' Council	489	..	..
W. Angliss Limited	17	..	..
Apple and Pear Marketing Board	284	..	..
Department of Commerce	618	..	..
Alfred Lawrence	470	..	..
Food Preservation Revenue Fund	109	..	..
		9,137	..
			18,146
(vii) Forest Products Problems	..	45,065	..
Less contributions from—			
Commonwealth Bank	4,000	..	..
Australian Paper Manufacturers Limited	500	..	..
Associated Pulp and Paper Mills Limited	500	..	..
Australian Newsprint Mills Limited	500	..	..
Tar Distillers' Research Committee	695	..	..
Department of Supply and Shipping	871	..	..
Department of Aircraft Production	179	..	..
Bureaux of Forestry	46	..	..
Miscellaneous contributions	451	..	..
		7,742	..
			37,323
(viii) Mining and Metallurgy	..	5,345	..
Less contributions from—			
Australasian Institute of Mining and Metallurgy		368	..
			4,977
(ix) Radio Research	..	8,267	..
Less contributions from—			
Postmaster-General's Department	3,950	..	..
Departments of Army, Navy, and Air	3,000	..	..
		6,950	..
			1,317
(x) Information Service including Library	..	6,070	..
Less contributions from Foreign Journal Service		485	..
			5,585
(xi) Fisheries Investigations	..	14,303	..
Less contributions from New South Wales Government		195	..
			14,108
(xii) Aeronautical Research	..	63,061	..
Less contributions from—			
Department of Aircraft Production	296	..	..
Department of Air	166	..	..
		462	..
			62,599
(xiii) National Standards Laboratory	..	88,163	..
Less contributions	..	31,405	..
			56,758
(xiv) Industrial Chemistry	..	57,428	..
Less contributions from—			
Department of Munitions	419	..	..
Australian Cement Manufacturers Association	1,185	..	..
National Gas Association	292	..	..
		1,896	..
			55,532
(xv) Miscellaneous—			
(*a*) Dairy Research	..	4,313	..
(*b*) Biometrics Section	..	3,673	..
(*c*) Lubricants and Bearings	14,175	..	..
Less contributions from University of Melbourne	520	..	..
		13,655	..
(*d*) Air Raid Precautions	811	..	..
Less contributions from Department of the Interior	789	..	..
		22	..
(*e*) Various	3,534	..	..
Less contributions from Department of Commerce	34	..	..
		3,500	..
			25,163
Total of Item 3—Investigations		..	388,545

2. Contributions and Donations.

The following statement shows the receipts and disbursements during the year 1942-43 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled "The Specific Purposes Trust Account":—

	Receipts 1942–43 and balances brought forward from 1941–42.	Expenditure 1942–43.
	£	£
Commonwealth Bank (Animal Health and Nutrition, Horticultural, Food Preservation and Transport, Prickly Pear, and Forest Products Investigations)	15,610	15,519
Australian Wool Board (Animal Health and Nutrition Investigations—Sheep Research)	13,606	9,232*
Australian Cattle Research Association (Mastitis Investigations)	3,000	3,000
George Aitken Pastoral Research Trust (Animal Health and Animal Nutrition Investigations—Sheep Research)	2,500	2,000
Queensland Government Cattle Research (Animal Health and Nutrition Investigations)	1,000	1,000
University of Sydney (Animal Health and Nutrition Investigations)	350	350
Australian Meat Board (Toxaemic jaundice investigations, Barooga, New South Wales)	135	135
C.P.P. Fairbairn (Animal Health and Nutrition Investigations—Footrot control)	30	..
Victorian Central Citrus Association—Citrus Problems (Plant Industry Investigations)	100	..
Tobacco Trust Fund—Prime Minister's Department—Tobacco Problems (Plant Industry Investigations)	15,153	1,850
Department of Supply and Shipping—Medicinal Plants (Plant Industry Investigations)	2,000	2,000
Commonwealth Bank—Bee Research (Entomological Investigations)	92	..
Ministry of Agriculture, Egypt, Cotton Investigations (Entomological Investigations)	79	79
Australian Wheat Board—Wheat Infestation (Entomological Investigations)	859	859†
Central Wool Committee—Wool Infestation (Entomological Investigations)	387	387
New South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	2,500	2,000
Murrumbidgee Irrigation Area Co-op. Society (Maintenance of Griffith Research Station)	8	8
Murrumbidgee Irrigation Area Executive Committee—Project Farm, Griffith Research Station	100	..
Mildura Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	249	248
Irymple Packing Company (Dried Vine Fruits Investigations, Merbein)	249	248
Red Cliffs Co-operative Fruit Company (Dried Vine Fruits Investigations, Merbein)	249	248
Aurora Packing Company (Dried Vine Fruits Investigations, Merbein)	249	248
Dried Fruits Control Board (Dried Fruits Investigations)	1,045	701
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	60	12
Department of Supply and Shipping (Production of Pyrethrum)	216	216
Riverstone Meat Coy. (Meat Investigations	100	..
Carried forward	59,926	40,340

	Receipts 1942–43 and balances brought forward from 1941–42.	Expenditure 1942–43.
	£	£
Brought forward	59,926	40,340
Australian Meat Board (Meat Investigations)	500	500
Metropolitan Meat Industry Commissioner of New South Wales (Meat Investigations)	500	500
Queensland Meat Industry Board (Meat Investigations)	850	850
Apple and Pear Marketing Board—Apple Juice Certification (Food Preservation Investigations)	294	284
New South Wales Department of Agriculture (Food Investigations)	800	800
A. Lawrence & Co. (Division of Food Preservation and Transport)	500	470
W. Angliss Ltd. (Division of Food Preservation and Transport)	17	17
L. Berger & Sons (Division of Food Preservation and Transport)	25	..
Batlow Packing House Co-op. Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations)	10	..
Lewis Berger & Sons Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations)	25	..
Egg Producers' Council (Division of Food Preservation and Transport—Egg Investigations)	613	489
Egg Producers' Council (Watery Whites in Eggs)	2	..
Department of Commerce and Agriculture (Division of Food Preservation and Transport—Dehydration Investigations)	2,500	618
Australian Paper Manufacturers Limited (Paper Pulp Investigations)	625	625‡
Associated Pulp and Paper Mills Limited (Paper Pulp Investigations)	500	500
Australian Newsprint Mills Pty. Ltd. (Paper Pulp Investigations)	500	500
Department of Aircraft Production (Forest Products and Aeronautics)	1,200	1,200§
Bureau of Forestry, Canberra, and Forest Services of Queensland, Victoria, New South Wales, and Western Australia—Wood Structure (Forest Products Investigations)	46	46
Tar Distillers Research Committee (Creosote Investigations)—Division of Forest Products	730	695
Sundry Contributors (Forests Products Investigations)	1,901	451
Australasian Dairy Council (Wood Taint in Butter Investigations)	11	..
Department of Supply and Development—Flax processing (Forest Products Investigations)	900	871
Brisbane Timber Merchants' Association (Division of Forest Products—Veneer and Gluing Work)	8	..
Australian Institute of Mining and Metallurgy (Mineragraphic Investigations)	368	368
Postmaster-General's Department (Radio Research)	4,122	3,951
Departments of Army, Navy and Air (Radio Research)	3,000	3,000
Sundry Contributions (Foreign Journal Service)	992	485
New South Wales Government (Fisheries Investigations)	209	209‖
Department of Air (Aeronautics)	200	166
National Gas Association (Gas Investigations — Industrial Chemistry)	292	292
Carried forward	82,166	58,227

* Includes £133 on account 1941–42 expenditure. † Includes £2 on account 1941–42 expenditure. ‡ Includes £125 on account 1941–42 expenditure.
§ Includes £725 on account 1941–42 expenditure. ‖ Includes £14 on account 1941–42 expenditure.

	Receipts 1942–43 and balances brought forward from 1941–42.	Expenditure 1942–43.
	£	£
Brought forward ..	82,166 ..	58,227
Australian Cement Manufacturers (Cement Investigations—Industrial Chemistry and Soils) ..	1,500 ..	1,500
Department of Commerce (Apple and Pear Investigations) ..	306 ..	34
Ministry of Munitions	31,846 ..	30,597*
Department of Navy	12,000 ..	1,398
Sundry Contributors (Council for Scientific and Industrial Research (Publications)	23 ..	..
Amalgamated Textiles (Aust.) Ltd. (Division of Industrial Chemistry)	35 ..	..
F. Walton & Co. (Division of Industrial Chemistry)	10 ..	..
Associated Woollen and Worsted Textile Manufacturers of Australia (Division of Industrial Chemistry	500 ..	..
Kelsall & Kemp (Tas.) Ltd. (Division of Industrial Chemistry) ..	50 ..	..
University of Melbourne (Friction Research)	520 ..	520
Department of Interior (A.R.P. expenditure)	2,597 ..	2,587†
Revenue Fund—Toxaemic Jaundice Investigations (Animal Health and Nutrition Investigations) ..	110 ..	..
Revenue Fund—Contagious Pleuropneumonia Investigations (Animal Health and Nutrition Investigations	791 ..	791
Revenue Fund—Oestrus Experiment (Animal Health and Nutrition Investigations)	192 ..	39
Revenue Fund—Oonoonba Research Station—Sale of Vaccine (Animal Health and Nutrition Investigations)	1,349 ..	1,349
Revenue Fund—Anaplasmosis Investigations (Animal Health and Nutrition Investigations) ..	26 ..	..
Revenue Fund—Parkville Laboratory (Animal Health and Nutrition Investigations)	635 ..	..
Revenue Fund—Werribee Farm (Mastitis Investigations) ..	2,731 ..	1,136
Revenue Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations	4,203 ..	3,542
Reserve Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Nutrition Investigations)	632 ..	..
Revenue Fund—Bacteriological Investigations (Animal Health and Nutrition Investigations) ..	45 ..	..
Revenue Fund — Parasitological Investigations (Animal Health and Nutrition Investigations) ..	377 ..	..
Revenue Fund—Infertility, F. D. McMaster Field Station (Animal Health and Nutrition Investigations)	1,182 ..	300
Revenue Fund—Nutrition Laboratory (Animal Health and Nutrition Investigations)	856 ..	255
Revenue Fund—Toxaemic Jaundice Investigations, Barooga, New South Wales (Animal Health and Nutrition Investigations) ..	1,161 ..	117
Revenue Fund—Plant Industry Investigations	636 ..	..
Revenue Fund—Entomological Investigations	451 ..	..
Revenue Fund—Griffith Research Station (Citricultural Investigations)	3,772 ..	1,784
Revenue Fund—Merbein Research Station (Viticultural Investigations)	7,339 ..	1,841
Carried forward ..	158,041 ..	106,017

	Receipts 1942–43 and balances brought forward from 1941–42.	Expenditure 1942–43.
	£	£
Brought forward ..	158,041 ..	106,017
Revenue Fund—Citrus Preservation Investigations	102 ..	..
Revenue Fund—Division of Food Preservation and Transport ..	172 ..	109
Revenue Fund—Egg Investigations, Egg Producers' Council (Division of Food Preservation and Transport)	130 ..	..
Revenue Fund—Mining and Metallurgy	14 ..	..
Revenue Fund—Ore-dressing Investigations	744 ..	..
Revenue Fund—Fisheries Investigations	13 ..	..
Revenue Fund—Division of Aeronautics	62 ..	..
Revenue Fund—National Standards Laboratory	119 ..	..
Revenue Fund—Dairy Investigations	5 ..	..
Revenue Fund — Industrial Chemistry	7 ..	..
	159,409	106,126

* Includes £171 on account 1941–42 expenditure.

† Includes £1,799 on account 1941–42 expenditure.

3. Staff.

The following is a list of the staff of the Council as at the 30th June, 1943. The list does not include typists, laboratory assistants and miscellaneous workers:—

1. Head Office Staff.

Chief Executive Officer—Sir David Rivett, K.C.M.G., M.A., D.Sc., F.R.S., F.A.C.I.

Deputy Chief Executive Officer—A. E. V. Richardson, C.M.G., M.A., D.Sc.

Secretary—G. Lightfoot, M.A.

Assistant Secretary and Officer-in-Charge, Information Section—G. A. Cook, M.Sc., B.M.E., F.A.C.I.

Assistant Secretary (Finance and Supplies)—M. G. Grace, A.I.C.A. (*vice* H. P. Breen, A.I.C.A., seconded).

Information Section—

J. E. Cummins, B.Sc., M.S., F.A.C.I. (seconded).
J. S. Hosking, M.Sc., Ph.D., A.I.C., A.A.C.I. (seconded from Division of Soils).
F. G. Nicholls, M.Sc., A.A.C.I. (seconded).
N. C. Hancox, M.Sc., A.A.C.I. (seconded from Division of Industrial Chemistry).
Miss M. E. Hamilton, B.Sc.
Miss M. Lee, B.Sc.
Miss J. Dunstone, B.Sc.

Library—

Librarian and Scientific Assistant—Miss E. Archer, M.Sc.
Assistant Librarian—Miss A. L. Kent.
Assistant Librarian—Miss F. V. Murray, M.Sc.

Accounts, Stores—

Accountant—D. J. Bryant, A.F.I.A. (*vice* M. G. Grace, A.I.C.A.).
R. W. Viney, A.I.C.A., A.A.I.S.
M. A. Elliott.
V. Leonard.
C. Munro (on service leave—R.A.N.V.R.).
F. Butler.
J. Farey (on service leave—A.I.F.).
F. J. Whitty (on service leave—A.I.F.).
R. Bennett (on service leave—A.I.F.).
J. Bourne (on service leave—A.I.F.).
C. Garrow, A.F.I.A. (on service leave—R.A.N.V.R.).
C. Cole (on service leave—R.A.N.V.R.).
K. Gamble (on service leave—R.A.A.F.).
B. Gaynor (on service leave—A.M.F.).
H. Lee (on service leave—R.A.A.F.).
J. M. Short (on service leave—A.I.F.).
K. J. Fogarty (on service leave—R.A.N.V.R.).
I. McMurdie.

Orders and Transport—

J. M. Derum.
L. Graham (on service leave—R.A.A.F.).

Staff—
R. D. Elder.
J. Smithwick (on service leave—R.A.A.F.).

Records—
P. Domee-Carre.
P. Knuckey.
R. McVilly, A.F.I.A.
B. Gooley (on service leave—R.A.A.F.).
M. Combe (on service leave—R.A.A.F.).
M. Reynolds (on service leave—A.M.F.).
Miss W. Livingston.
D. Yarr (on service leave—R.A.A.F.).

Head Typiste—
Miss B. M. Thomas.

Clerical Assistant to Chief Executive Officer—Miss A. Slattery, B.A.
Clerical Assistant to Chairman—Mrs. N. E. Roberts.
Senior Clerical Officer, Sydney—R. F. Williams.
Architect—W. R. Ferguson, B.E., A.R.A.I.A.

2. Secretaries of State Committees.

New South Wales—
Mrs. N. E. Roberts, 906 Culwulla Chambers, Castlereagh-street, Sydney.

Victoria—
G. A. Cook, M.Sc., B.M.E., F.A.C.I., 314 Albert-street, East Melbourne.

Queensland—
Miss H. F. Todd, 113 Eagle-street, Brisbane.

South Australia—
J. Ward Walters, Animal Nutrition Laboratory, University of Adelaide.

Western Australia—
R. P. Roberts, M.Sc.(Agric.), Dept. of Agriculture, St. George's-terrace, Perth.

Tasmania—
F. J. Carter, c/o Premier's Office, Hobart.

3. Australia House, London.

Representative in Britain—F. L. McDougall, C.M.G. (part-time).

4. Division of Plant Industry.

At Canberra—
Administration—
Chief—B. T. Dickson, B.A., Ph.D.
Librarian (half-time)—Miss A. Nicholson (acting).
Senior Clerical Officer (half-time)—D. Banyard (acting).
Clerk, Records—K. J. Prowse (on service leave—A.I.F.).
Clerk, Records—T. A. Lewis (on service leave—R.A.A.F.).
Pathology—
Principal Research Officer—H. R. Angell, O.B.E., Ph.D.
Research Officer—J. G. Bald, M.Agr.Sc., Ph.D.
Research Officer—W. V. Ludbrook, B.Ag.Sc., Ph.D. (on service leave—R.A.A.F.).
Assistant Research Officer—N. H. White, M.Sc.
Assistant Research Officer—D. O. Norris, B.Sc. (Agric.).
Genetics—
Principal Research Officer—J. R. A. McMillan, D.Sc.Agr., M.S.
Research Officer—K. L. Hills, B.Agr.Sc.
Assistant Research Officer—F. W. Hely, B.Sc.Agr.
Assistant Research Officer—E. M. Hutton, B.Ag.Sc., M.Sc.
Assistant Research Officer—S. G. Gray, B.Sc.Agr.
Plant Introduction—
Senior Research Officer—A. McTaggart, M.S.A., Ph.D.
Research Officer—W. Hartley, B.A., Dip.Ed.
Horticultural and General Botany—
Senior Research Officer—C. Barnard, D.Sc.
Vegetable Fibre Investigations—
Research Officer—A. V. Hill, M.Agr.Sc.
Research Officer—J. Calvert, D.Sc., F.L.S. (on service leave—R.A.A.F.).
Agrostology—
Senior Research Officer—J. G. Davies, B.Sc., Ph.D.
Research Officer—C. M. Donald, M.Ag.Sc. (seconded).
Assistant Research Officer—R. Roe, B.Sc. (Agric.).
Assistant Research Officer—R. M. Moore, B.Sc.Agr. (on service leave—R.A.A.F.).
Assistant Research Officer—N. Shaw, B.Agr.Sc. (seconded).
Assistant Research Officer—T. Wilkinson, B.Sc. (on service leave—A.I.F.).
Assistant Research Officer—W. M. Willoughby, B.Sc.Agr.
Assistant Research Officer—E. H. Kipps, B.Sc.
Technical Officer—Miss N. Barrie, B.Sc.Agr.
Tobacco Investigations—
Research Officer—A. V. Hill, M.Agr.Sc.
Assistant Research Officer—K. F. Plomley, B.Sc.Agr. (on service leave—R.A.N.).
Technical Officer—G. H. Marks.
Drug Plant Investigations—
Senior Research Officer—C. Barnard, D.Sc.
Research Officer—K. L. Hills, B.Agr. Sc.
Assistant Research Officer—N. H. White, M.Sc.
Rubber Plant Investigations—
Senior Research Officer (guayule)—A. McTaggart, M.S.A., Ph.D.
Senior Research Officer (T. Kok-saghyz)—J. G. Davies, B.Sc., Ph.D.
Research Officer (guayule)—W. Hartley, B.A., Dip.Ed.
Technical Officer (T. Kok-saghyz)—C. W. E. Moore, B.Agr.Sc.
Special Officer (Cryptostegia)—R. S. Dwyer.
At Dickson Experiment Station, Canberra—
Manager—L. Sharp, Dip.Agr.
At Griffith, New South Wales—
Assistant Research Officer (horticultural physiology)—Miss J. Hearman, B.Sc., Ph.D.
At Queensland Agricultural High School and College, Lawes—
Research Officer (genetics)—C. S. Christian, B.Agr.Sc., M.Sc.
Research Officer (plant introduction)—T. B. Paltridge, B.Sc.
At Stanthorpe, Queensland—
Research Officer (horticultural investigations)—L. A. Thomas, M.Sc.
At Fitzroyvale, Central Queensland—
Assistant Research Officer (plant introduction)—J. F. Miles, B.Agr.Sc.
At Muresk, Western Australia—
Assistant Research Officer (plant introduction)—E. T. Bailey, B.Sc.
At University of Melbourne—
Assistant Research Officer (weeds investigations)—R. W. Prunster, B.Sc. (Agric.) (seconded).
At Huonville, Tasmania—
Research Officer (fruit investigations)—D. Martin, B.Sc.
At University of Western Australia, Perth—
Research Officer (agrostology)—A. B. Cashmore, M.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer (agrostology)—R. C. Rossiter, B.Sc. (Agric.).

5. Division of Economic Entomology.

At Canberra—
Administration—
Chief—A. J. Nicholson, D.Sc.
Librarian (half-time)—Miss A. Nicholson (acting).
Senior Clerical Officer (half-time)—D. Banyard (acting).
Clerk, Records—K. J. Prowse (on service leave—A.I.F.).
Clerk, Records—T. Lewis (on service leave—R.A.A.F.).
Wheat Pest and Termite Investigations—
Senior Research Officer—F. N. Ratcliffe, B.A. (on service leave—A.I.F.).
Research Officer—F. J. Gay, B.Sc., D.I.C.
Technical Officer—T. Greaves.
Wool Pest Investigations—
Research Officer—K. H. L. Key, M.Sc., Ph.D., D.I.C.
Assistant Research Officer—K. R. Norris, M.Sc.
Veterinary Entomology—
Principal Research Officer—I. M. Mackerras, B.Sc., M.B., Ch.M. (on service leave—A.I.F.).
Research Officer (blowfly investigations)—Mrs. M. J. Mackerras, M.Sc., M.B. (on extended leave).
Assistant Research Officer (blowfly investigations)—D. F. Waterhouse, M.Sc., A.A.C.I.
Assistant Research Officer (blowfly investigations)—D. Gilmour, M.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer (blowfly investigations)—R. W. Kerr, B.Sc.
Agricultural Entomology and Museum—
Assistant Research Officer—T. G. Campbell.
Technical Officer (photography)—W. J. James (on service leave—R.A.A.F.).
Toxicology Investigations—
Technical Officer—R. F. Powning, A.S.T.C., A.A.C.I.
Insect Vectors of Virus Diseases—
Assistant Research Officer—G. A. Helson, M.Sc.
Locust Investigations—
Research Officer—K. H. L. Key, M.Sc., Ph.D., D.I.C.
At Warren, New South Wales—
Assistant Research Officer (locust investigations)—L. R. Clark, M.Sc.
Technical Officer (locust investigations)—D. L. Hall, Dip.Agr. (on service leave—R.A.A.F.).
Technical Officer—A. T. Mills.
At Melbourne, Victoria—
Research Officer (wheat investigations)—F. Wilson.
At School of Veterinary Science, Brisbane—
Senior Research Officer (cattle tick investigations)—L. F. Hitchcock, M.Sc.

6. Division of Animal Health and Nutrition.

At Animal Health Research Laboratory and Divisional Headquarters, Melbourne—
Chief—L. B. Bull, D.V.Sc.
Divisional Secretary—A. J. Vasey, B.Agr.Sc.
Chief Bacteriologist and Officer-in-Charge—A. W. Turner, O.B.E., D.Sc., D.V.Sc.
Senior Research Officer—D. Murnane, B.V.Sc. (pathology, bacteriology, dairy cattle) (on service leave).
Senior Research Officer—A. D. Campbell, L.V.Sc. (serological investigations).
Research Officer (immuno-chemistry)—A. T. Dann, M.Sc., A.A.C.I.
Research Officer (bacteriology, dairy cattle)—E. Munch-Petersen, M.Sc., Ph.B., M.I.F.
Research Officer (bacteriology—biochemistry)—A. T. Dick, M.Sc., A.A.C.I.
Assistant Research Officer (bacteriology, anaerobic infections)—A. W. Rodwell, M.Sc.
Assistant Research Officer (field studies, dairy cattle diseases)—L. Duckett, Dr.Med.Vet. (Brno).
Technical Officer—Miss C. E. Eales, B.Sc.
Technical Officer—Miss M. J. Monsbourgh, B.Sc.
Technical Officer—H. G. Turner, B.Agr.Sc.
Technical Officer—E. Wold.
Technical Officer—A. E. Wright.
Technical Officer—J. J. Spencer (on service leave—A.I.F.).
Librarian—Miss F. V. Murray, M.Sc. (part-time).
Clerk—J. Foley (on service leave—A.I.F.).

At F. D. McMaster Animal Health Laboratory, Sydney—
Officer-in-Charge—D. A. Gill, M.R.C.V.S., D.V.S.M. (seconded).
Principal Research Officer (bacteriology)—T. S. Gregory, B.V.Sc. (on service leave—A.I.F.).
Senior Research Officer and Acting Officer-in-Charge (parasitology)—H. McL. Gordon, B.V.Sc.
Senior Research Officer (biochemistry)—M. C. Franklin, M.Sc., Ph.D. (Cantab.), A.I.C.
Senior Research Officer (bacteriology, sheep diseases)—W. I. B. Beveridge, D.V.Sc. (seconded).
Research Officer (field investigations, ectoparasites)—N. P. H. Graham, B.V.Sc.
Research Officer (chemistry of wool)—M. R. Freney, B.Sc., A.A.C.I. (seconded).
Research Officer (wool biology)—H. B. Carter, B.V.Sc.
Research Officer (parasitology, field studies)—I. W. Montgomery, B.V.Sc. (on service leave).
Assistant Research Officer (blowfly strike, field studies).—I. L. Johnstone, B.V.Sc.
Assistant Research Officer (parasitology, field studies)—F. H. Ward, B.V.Sc.
Assistant Research Officer (biochemistry)—C. R. Austin, B.V.Sc. (seconded).
Technical Officer—E. Parrish.
Librarian—Miss B. Johnston, B.Sc. (part-time).
Clerk—H. H. Wilson (on service leave—R.A.A.F.).

At Animal Nutrition Laboratory, Adelaide—
Chief Nutrition Officer and Officer-in-Charge—H. R. Marston, F.A.C.I.
Secretary—J. Ward Walters.
Senior Research Officer (metabolism)—E. W. Lines, B.Sc. (on service leave).
Research Officer (biochemistry)—J. W. H. Lugg, Ph.D., D.Sc., F.I.C., A.A.C.I.
Research Officer (ruminant physiology)—R. H. Watson, B.Agr.Sc. (seconded).
Research Officer (agrostology)—D. S. Riceman, B.Ag.Sc.
Research Officer (mineral deficiency, field investigations)—H. J. Lee, B.Sc.
Assistant Research Officer (biochemistry)—A. B. Beck, M.Sc., A.A.C.I.
Assistant Research Officer (metabolism)—F. V. Gray, B.Sc. (on service leave—A.I.F.).
Assistant Research Officer (metabolism)—T. A. F. Quinlan-Watson, B.Sc.
Technical Officer—J. O. Wilson.
Technical Officer—F. C. Farr.
Technical Officer—I. G. Jarrett, B.Sc.
Technical Officer—A. F. Pilgrim, B.Sc. (on service leave—R.A.N.).
Technical Officer—D. W. Dewey.
Statistical Recorder—G. W. Bussell.

At Waite Agricultural Research Institute, Adelaide—
Research Officer (studies in experimental nutrition)—A. W. Peirce, M.Sc., A.A.C.I.

At F. D. McMaster Field Station, Badgery's Creek, New South Wales—
Principal Research Officer and Officer-in-Charge (animal genetics)—R. B. Kelley, D.V.Sc.
Technical Officer—C. R. Graham.

At National Field Station, "Gilruth Plains," Cunnamulla, Queensland—
Research Officer-in-Charge—J. H. Riches, B.Sc. (Agric.), Ph.D.
Station Manager—W. S. Firth.

At Institute of Agriculture, University of Western Australia—
Assistant Research Officer (biochemistry)—S. T. Evans, B.Sc., A.A.C.I.

7. Mineral Deficiency of Pastures Investigation.

At Waite Agricultural Research Institute—
Assistant Research Officer (chemist)—R. E. Shapter, A.A.C.I.

8. Division of Soils.

At Waite Agricultural Research Institute—
Chief—J. A. Prescott, D.Sc., A.A.C.I. (part-time).
Principal Research Officer (soil surveys)—J. K. Taylor, B.A., M.Sc., B.Sc.Agr.
Research Officer (soil surveys)—T. J. Marshall, M.Ag.Sc., Ph.D.
Research Officer (soil surveys)—C. G. Stephens, M.Sc., A.A.C.I.
Research Officer (soil chemistry)—J. S. Hosking, M.Sc., Ph.D., A.I.C., A.A.C.I. (seconded).
Research Officer (soil chemistry)—A. Walkley, B.A., B.Sc., Ph.D., A.I.C., A.A.C.I. (seconded).
Assistant Research Officer (spectrography)—A. C. Oertel, M.Sc., A.A.C.I.
Assistant Research Officer (microbiology)—T. H. Strong, M.Agr.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer (soil surveys)—J. G. Baldwin, B.Agr.Sc., B.Sc. (on service leave—A.I.F.).
Assistant Research Officer (soil surveys)—G. D. Hubble, B.Ag.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer (soil surveys and ecology)—R. L. Crocker, M.Sc. (seconded).
Assistant Research Officer (soil surveys)—B. E. Butler, B.Sc. (Agric.) (on service leave—R.A.A.F.).
Assistant Research Officer (soil surveys)—R. Smith, B.Sc. (Agric.).
Assistant Research Officer (soil surveys)—R. G. Downes, M.Agr.Sc.
Assistant Research Officer (soil surveys)—E. J. Johnston, B.Sc.Agr. (on service leave—R.A.A.F.).
Assistant Research Officer (soil surveys)—T. Langford Smith, B.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer—R. Brewer, B.Sc. (on service leave—R.A.A.F.).
Assistant Research Officer—Miss M. P. Thomas, B.Sc.
Technical Officer (surveys and cartography)—P. D. Hooper.
Technical Assistant (soil chemistry)—H. R. Skewes (seconded).

9. Irrigation Settlement Problems.

At Irrigation Research Station, Griffith—
Officer-in-Charge—E. S. West, B.Sc., M.S.
Chemist—A. Howard, M.Sc., A.A.C.I. (seconded).
Research Officer—R. R. Pennefather, B.Agr.Sc.
Assistant Research Officer—O. Perkman, B.Sc.Agr.
Assistant Research Officer—V. J. Wagner, B.Agr.Sc.
Assistant Research Officer—E. L. Greacen, B.Sc.Agr.
Assistant Research Officer—K. Spencer, B.Sc.Agr.
Orchard Superintendent—B. H. Martin, H.D.A.
Technical Officer—T. J. Masters.

At Commonweath Research Station, Merbein—
Officer-in-Charge—A. V. Lyon, M.Agr.Sc.
Senior Research Officer (chemist)—E. C. Orton, B.Sc., A.I.C., A.A.C.I.
Assistant Research Officer (irrigation and viticulture)—D. V. Walters, M.Agr.Sc.
Assistant Research Officer—A. L. Tisdall, M.Agr.Sc. (on service leave—R.A.A.F.).
Technical Officer—J. E. Giles.
Research Officer—R. C. Polkinghorne (part-time).

10. Division of Forest Products.

At South Melbourne—
Administration—
Chief—I. H. Boas, M.Sc., A.A.C.I.
Deputy Chief—S. A. Clarke, B.E., A.M.I.E.(Aust.) (on leave).
Principal Research Officer—C. S. Elliott, B.Sc.
Librarian and Records Clerk—Miss M. I. Hulme.
Chemistry Section—
Principal Research Officer-in-Charge—W. E. Cohen, D.Sc., A.A.C.I.
Research Officer (chemist)—Miss T. M. Reynolds, M.Sc., D.Phil., A.A.C.I. (seconded).
Research Officer (chemist)—D. E. Bland, M.Sc.
Assistant Research Officer—A. J. Watson, A.A.C.I.
Technical Officer—A. G. Charles, A.A.C.I.

Wood Structure Section—
Principal Research Officer-in-Charge—H. E. Dadswell, D.Sc., A.A.C.I.
Assistant Research Officer—H. D. Ingle, B.For.Sc. (N.Z.).
Assistant Research Officer—Miss A. M. Eckersley, M.Sc.
Assistant Research Officer—Miss D. J. Ellis, B.Sc.
Seasoning Section—
Assistant Research Officer-in-Charge—G. W. Wright, B.E.
Assistant Research Officer—A. C. Pond, B.E. (Hons.) (on service leave—R.A.A.F.).
Technical Officer—J. T. Currie.
Technical Officer—H. D. Roberts.
Timber Physics Section—
Senior Research Officer-in-Charge—W. L. Greenhill, M.E., Dip.Sc.
Assistant Research Officer—P. H. Sulzberger, B.Sc.
Timber Mechanics Section—
Senior Research Officer-in-Charge—I. Langlands, B.E.E., M.Mech.E., A.M.I.E., Aust.
Assistant Research Officer—R. S. T. Kingston, B.Sc., B.E.
Assistant Research Officer—N. H. Kloot, B.Sc.
Technical Officer—B. Whitington, B.Sc., B.E.
Technical Officer—J. J. Mack.
Technical Officer—G. Barrow.
Preservation Section—
Research Officer-in-Charge—S. F. Rust, B.Sc., M.S.
Assistant Research Officer—H. B. Wilson, B.Sc., A.A.C.I.
Assistant Research Officer—N. Tamblyn, M.Sc. (Agric.).
Veneering and Gluing Section—
Research Officer-in-Charge—S. F. Rust, B.Sc., M.S.
Research Officer—C. E. Dixon, M.Sc., A.A.S.E.
Assistant Research Officer—G. W. Tack, B.Agr.Sc.
Assistant Research Officer—J. S. McCrea, B.Agr.Sc.
Assistant Research Officer—M. D. Fry, B.Sc.
Technical Officer—R. Deeble.
Technical Officer—M. W. Mules (seconded from Division of Animal Health and Nutrition).
Timber Utilization Section—
Senior Officer-in-Charge—R. F. Turnbull, B.E.(Hons.) (seconded).
Research Officer—A. J. Thomas, Dip.For. (seconded).
Assistant Research Officer-in-Charge (acting)—A. Gordon, B.Sc.
Technical Officer—A. Rosel.
Flax Processing—
Senior Research Officer-in-Charge—W. L. Greenhill, M.E., Dip.Sc.
Research Officer—A. M. Munro, M.A.(Oxon.), A.I.C., F.C.S.
Assistant Research Officer—Miss J. F. Couchman, B.Sc., A.A.C.I.
Assistant Research Officer—Miss W. M. P. Cook, B.Sc.
Technical Officer—M. Tisdall.
Photography—
Technical Officer—E. S. Smith.
Technical Officer—Miss A. M. Lightfoot.
Maintenance Section—
Technical Officer—S. G. McNeil.

11. Division of Food Preservation and Transport.

At State Abattoir, Sydney—
Chief—J. R. Vickery, M.Sc., Ph.D., A.A.C.I.
Librarian—Miss B. Johnston, B.Sc. (part-time).
Physics Section—
Officer-in-Charge—E. W. Hicks, B.A., B.Sc., A.A.C.I.
Assistant Research Officer—M. C. Taylor, M.Sc.
Fruit Storage Section—
Officer-in-Charge—S. A. Trout, M.Sc., Ph.D.
Canning and Fruit Products Section—
Officer-in-Charge—L. J. Lynch, B.Agr.Sc.
Senior Research Officer—W. A. Empey, B.V.Sc.
Research Officer—F. E. Huelin, B.Sc., Ph.D., A.A.C.I.
Assistant Research Officer—J. F. Kefford, M.Sc., A.A.C.I.
Assistant Research Officer—R. S. Mitchell, M.Sc.Agr.
Technical Officer—Mrs. I. M. Stephens, B.Agr.Sc.
Technical Officer—Mrs. G. Robertson, B.Sc.
Dried Foods Section—
Research Officer—Miss T. M. Reynolds, M.Sc., D.Phil., A.A.C.I. (seconded from Division of Forest Products).
Research Officer—A. Howard, M.Sc., A.A.C.I. (seconded from Irrigation Research Station, Griffith).
Assistant Research Officer—C. R. Austin, M.Sc., B.V.Sc.
Assistant Research Officer—H. S. McKee, B.A., D.Phil.
Assistant Research Officer—S. M. Sykes, B.Sc.Agr.
Assistant Research Officer—A. R. Prater, B.Sc.Agr.
Assistant Research Officer—D. McG. McBean, B.Sc.
Assistant Research Officer—J. Shipton, B.Sc.Agr.
Microbiology Section—
Officer-in-Charge—W. J. Scott, B.Agr.Sc.
Senior Bacteriologist—D. F. Stewart, B.V.Sc., Dip.Bact. (seconded from N.S.W. Department of Agriculture).
Assistant Research Officer—A. M. Olsen, B.Sc.
Technical Officer—P. R. Maguire.
At Division of Animal Health and Nutrition, Melbourne—
Assistant Research Officer (bacteriologist)—J. M. Gillespie, M.Sc., A.A.C.I.
At Brisbane Abattoir—
Research Officer—A. R. Riddle, M.A., M.Sc.
Assistant Research Officer—Miss B. M. Brims, B.Sc.
At Fisheries Research Laboratory, Cronulla—
Assistant Research Officer (chemist)—C. G. Setter, B.Sc.
At Australia House, London—
Research Officer—N. E. Holmes, B.E.E., M.Mech.E.

12. Division of Fisheries.

At Port Hacking, Sydney—
Chief—H. Thompson, M.A., D.Sc.
Research Officer (bacteriologist)—E. J. Ferguson Wood, M.Sc., B.A.
Assistant Research Officer (biologist)—G. L. Kesteven, B.Sc.
Assistant Research Officer (biologist)—A. Tubb, M.Sc.
Assistant Research Officer (biologist)—G. P. Whitley (seconded from Royal Australian Museum).
Assistant Research Officer (chemist and hydrographer)—D. Rochford, B.Sc.
Assistant Research Officer (biochemist)—C. G. Setter, B.Sc., A.A.C.I., A.M.T.C. (seconded).
Assistant Research Officer (biologist)—Mrs. L. Willings, B.A.
Technical Officer (laboratory)—A. Proctor.
Technical Officer—K. Sheard.
Technical Officer—R. Allan.
At Perth—
Research Officer (biologist)—D. L. Serventy, B.Sc., Ph.D.
At Melbourne—
Fisheries Officer—S. Fowler.
Assistant Research Officer—M. Blackburn, M.Sc.

13. Australian National Standards Laboratory.

Administration—
Officer-in-Charge—N. A. Esserman, B.Sc., F.Inst.P., A.M.I.E. Aust.
Senior Clerical Officer—R. F. Williams.
Clerk—S. J. Cossar (on service leave—A.I.F.).
Clerk—W. J. Gillespie (seconded from Division of Fisheries).
Drawing Office—
Designing Draughtsman—C. Williamson.
Draughtsman, Grade I.—R. H. Furniss.
Draughtsman, Grade I.—A. G. Chinnery.
Library—
Librarian—Miss M. Barnard, B.A.
Assistant Librarian—Miss B. Mortlock, B.A.
Assistant Librarian—Miss P. Adamson, B.Sc.
Workshop—
Foreman-Supervisor—J. Hanna.
Sub-Foreman—H. G. Pincott.
Instrument Maker—F. Boland.
Instrument Maker—A. H. Masters.
Tool Maker—D. A. Greenwood.
Fitter and Turner—D. J. Harper.
Electrical Fitter—C. F. Collins.
Maintenance Electrician—N. Wunderlich.
Plumber-Tinsmith—W. D. Palmer.
Patternmaker-Carpenter—A. Taylor.
Chargehand—W. Hyett.
Chargehand—L. T. Mills.
Chargehand—J. W. Porter.
Metrology Section—
Officer-in-Charge—N. A. Esserman, B.Sc., F.Inst. P., A.M.I.E. Aust.
Research Officer—P. M. Gilet, B.Sc., B.E., A.Inst.P.
Research Officer—C. G. Greenham, M.Sc.
Assistant Research Officer—E. E. Adderley, B.Sc.
Assistant Research Officer—Miss A. Alexander, B.Sc.
Assistant Research Officer—J. V. Bainton, B.E.
Assistant Research Officer—G. A. Bell, B.Sc., A.Inst.P.
Assistant Research Officer—C. F. Bruce, M.Sc. (N.Z.).
Assistant Research Officer—Miss A. Conochie, B.Sc.
Assistant Research Officer—W. A. F. Cuninghame, B.E.
Assistant Research Officer—H. H. Davis, B.Sc., B.E., Ph.D. (Cantab.).
Assistant Research Officer—Miss I. Dewhurst, B.Sc., B.Ed.
Assistant Research Officer—Miss M. Dive, B.Sc.
Assistant Research Officer—M. F. Lamrock, B.Sc., B.E.
Assistant Research Officer—Miss M. Pearce, M.Sc.
Assistant Research Officer—Miss P. Weine, B.Sc.
Assistant Research Officer—Miss P. Yelland.
Assistant Research Officer—Miss E. York, B.Sc.
Testing Engineer, Grade II.—R. A. Holloway, B.Sc., B.E., A.Inst.E.(Aust.), (on loan from N.S.W. Railways).
Electrotechnology Section—
Officer-in-Charge—D. M. Myers, B.Sc., D.Sc.Eng., A.M.I.E.E., F.Inst.P.
Research Officer—W. K. Clothier, B.Sc., M.E., A.Inst.P.
Assistant Research Officer—G. J. A. Cassidy, B.E.E.
Assistant Research Officer—P. A. Champion, B.E.

Assistant Research Officer—D. J. Cole, B.E.E.
Assistant Research Officer—Miss M. Douglas, B.Sc.
Assistant Research Officer—F. A. Edwards, B.E.
Assistant Research Officer—B. V. Hamon, B.Sc., B.E.
Assistant Research Officer—A. H. Hean, B.E.
Assistant Research Officer—H. W. Stokes, B.Ec.
Assistant Research Officer—A. M. Thompson, B.Sc.
Assistant Research Officer—Miss N. Watts, B.A.
Assistant, Clerical—Miss G. Levy, B.A.

Physics Section—
Officer-in-Charge—G. H. Briggs, D.Sc., Ph.D., F.Inst.P.
Research Officer—A. F. A. Harper, M.Sc., A.Inst.P.
Assistant Research Officer—H. Corker, B.Sc.
Assistant Research Officer—N. A. Faull, B.Sc.
Assistant Research Officer—R. Giovanelli, M.Sc.
Assistant Research Officer—W. R. G. Kemp, B.Sc.
Assistant Research Officer—R. T. Leslie, B.A., B.Sc.
Assistant Research Officer—E. H. Mercer, B.Sc., A.Inst.P.
Assistant Research Officer—J. W. Pearce, B.Sc.
Assistant Research Officer—H. F. Pollard, B.Sc., A.Inst.P.
Technician—J. E. Thompson.
Assistant, Clerical—Miss E. Andrews, B.A.

14. Division of Aeronautics.

Administrative—
Chief—L. P. Coombes, D.F.C., B.Sc.(Eng.), A.F.R.Ae.S., A.F.I.Ae.S., A.M.I.E. Aust.
Secretary—B. McA. Foster, B.C.E., D.I.C., A.F.R.Ae.S.
Clerk—Mrs. E. M. Coxon.

Structures and Materials Section—
Principal Research Officer—H. A. Wills, B.E., A.F.R.Ae.S.
Research Officer—F. S. Shaw, B.E.
Assistant Research Officer—W. W. Johnstone, B.E.
Assistant Research Officer—W. I. B. Smith, B.Sc.
Assistant Research Officer—R. C. T. Smith, B.A., B.Sc.
Technical Officer—J. P. O. Silberstein.
Technical Officer—F. A. Dale.
Technical Officer—A. T. Taylor, B.Sc.(Eng.), B.Sc.
Technical Officer—A. N. Pickering.

Metallurgy—
Officer-in-Charge (on loan from North American Cyanamid Co.)—G. B. O'Malley, B.Met.E., M.Aust.I.M.M., M.Inst.M., M.A.I.M.E. (part-time).
Assistant Research Officer—J. B. Dance, B.Met.E.
Assistant Research Officer—A. R. Edwards, B.Met.E.
Assistant Research Officer—H. L. Wain, B.Met.E.
Assistant Research Officer—C. J. Osborn, B.Met.E.

Aerodynamics Section—
Senior Research Officer—G. N. Patterson, B.Sc., M.A., Ph.D., A.F.R.Ae.S.
Research Officer—T. F. C. Lawrence, B.Sc., B.E.
Assistant Research Officer—G. K. Batchelor, M.Sc.
Assistant Research Officer—J. B. Willis, M.Sc.
Assistant Research Officer—R. W. Cumming, B.E.
Assistant Research Officer—J. F. M. Scholes, B.Eng.Sc., B.E. (Aero.).
Assistant Research Officer—F. G. Blight, B.Sc., B.E. (Aero.).
Assistant Research Officer—G. S. Watson, B.A.
Assistant Research Officer—A. F. Pillow, B.A.
Technical Officer—F. Redlich, Dipl. Ing.
Technical Officer—G. J. Dailey.
Technical Officer—H. J. Major.
Technical Officer—G. F. Gerrand.
Technical Officer—L. T. Watson.
Technical Officer—P. C. a'B. Chomley.

Engines and Fuels Section—
Senior Research Officer—M. W. Woods, D.Phil., B.Sc., B.E., A.M.I.E. Aust.
Research Officer—T. S. Keeble, B.E., B.Sc.
Assistant Research Officer—W. B. Kennedy, B.Mech.E.
Assistant Research Officer—W. H. Clements, B.Sc.
Assistant Research Officer—J. C. Wisdom, B.Mech.E.
Assistant Research Officer—R. A. Wright, B.Sc.(E).

Instruments Section—
Assistant Research Officer—A. A. Townsend, M.Sc.

Drawing Office and Workshops—
Supervisor—D. W. Eaton.

Photography—
Technical Officer—Miss E. F. Lightfoot.

15. Division of Industrial Chemistry.

Administrative and General—
Chief—I. W. Wark, Ph.D., D.Sc., F.A.C.I., M.A.I.M.E.
Divisional Secretary—L. Lewis, B.Met.E.
Clerk—A. Patterson, A.F.I.A.
Clerk—Miss E. M. Wright.

Biochemistry Section—
Research Officer—F. G. Lennox, D.Sc., A.A.C.I.
Assistant Research Officer—W. J. Ellis, A.S.T.C., A.A.C.I.
Assistant Research Officer—Miss M. E. Maxwell, M.Sc., A.A.C.I.
Assistant Research Officer—Miss A. M. McArthur, M.Sc., A.A.C.I.

Minerals Utilization Section—
Senior Research Officer—R. G. Thomas, B.Sc., A.A.C.I.
Research Officer—A. Walkley, B.A., B.Sc., Ph.D., A.I.C., A.A.C.I. (seconded from Division of Soils).
Assistant Research Officer—A. W. Wylie, M.Sc., Ph.D., A.I.C., A.A.C.I.
Assistant Research Officer—P. Dixon, M.Sc., A.A.C.I. (seconded from Commonwealth Research Station, Merbein).
Assistant Research Officer—G. B. Gresford, B.Sc., A.M.T.C., A.A.C.I. (seconded).
Assistant Research Officer—F. K. McTaggart, M.Sc., A.A.C.I.
Assistant Research Officer—T. R. Scott, M.Sc., B.Ed., A.A.C.I.
Assistant Research Officer—F. R. Hartley, M.Sc., A.A.C.I.
Assistant Research Officer—R. C. Croft, B.Sc.
Assistant Research Officer—A. D. Wadsley, M.Sc., A.A.C.I.
Technical Officer—K. L. Elliot.
Technical Officer—V. A. C. Bertrand.

Dairy Products Section—
Research Officer—G. Loftus Hills, B.Agr.Sc.
Assistant Research Officer—J. Conochie, B.Sc.(Agric.).
Technical Officer—W. G. T. Laffan, H.D.D.

Organic Section—
Senior Research Officer—H. H. Hatt, B.Sc., Ph.D., A.I.C., A.A.C.I.
Research Officer—J. S. Fitzgerald, M.Sc., Ph.D., A.A.C.I.
Assistant Research Officer—N. C. Hancox, M.Sc., A.A.C.I. (seconded).
Assistant Research Officer—K. E. Murray, B.Sc., A.I.C., A.A.C.I.
Assistant Research Officer—R. G. Curtis, M.Sc., A.A.C.I.
Assistant Research Officer—R. J. L. Martin, M.Sc., A.A.C.I.
Assistant Research Officer—A. G. Dobson, M.Sc.
Technical Officer—L. K. Dalton, D.S.T.C., A.A.C.I.
Technical Officer—K. H. Otway.
Technical Officer—W. E. Hillis, A.G.Inst.Tech.

Physical Chemistry Section—
Research Officer—K. L. Sutherland, M.Sc., A.A.C.I.
Assistant Research Officer—J. Rogers, M.Sc., A.A.C.I.
Assistant Research Officer—Miss E. Plante, B.Sc., A.A.C.I.
Assistant Research Officer—R. J. Goldacre, B.Sc.(Hons.), (seconded from Dept. of Agr. N.S.W.).
Technical Officer—L. F. Evans.

Foundry Sands Investigations—
Assistant Research Officer—H. A. Stephens, B.Sc.
Technical Officer—G. V. Cullen.

Cement Section—
Research Officer—A. R. Alderman, D.Sc., Ph.D., F.G.S.
Assistant Research Officer—A. J. Gaskin, M.Sc.
Assistant Research Officer—H. E. Vivian, B.Sc.Agr.

Physical Metallurgy Section—
Officer-in-Charge (on loan from North American Cyanamid Co.)—G. B. O'Malley, B.Met.E., M.Aust.I.M.M., M.Inst.M., M.A.I.M.E. (part-time).
Assistant Research Officer—H. W. Worner, M.Sc., A.A.C.I.
Assistant Research Officer—J. H. Buckley, B.Sc.
Metallurgist—H. T. Greenaway, B.Met.E. (on loan from Broken Hill Associated Smelters Pty. Ltd.).
Technical Officer—K. R. Hanna.

Chemical Engineering Section—
Principal Research Officer—E. J. Drake, A.A.C.I. (seconded).
Assistant Research Officer—E. H. Waters, M.Sc.(Hons.) (seconded).
Assistant Research Officer—D. R. Zeidler, M.Sc., A.A.C.I.
Assistant Research Officer—I. Brown, B.Sc., A.A.C.I.
Assistant Research Officer—R. W. Urie, B.Sc.
Assistant Research Officer—J. F. Pearse, B.Sc.(Hons.), A.A.C.I.
Technical Officer—J. Coutts, A.M.T.C.
Technical Officer—J. L. Clay, A.M.T.C., A.A.C.I.
Senior Draughtsman—C. Simpson.
Draughtsman—H. H. Evans.
Draughtsman—L. R. Bull.
Tracer—Miss M. M. Meehan.

Analytical Section—
Research Officer—A. Lench, B.Sc., Dip.Ed.
Assistant Research Officer—E. S. Pilkington, A.S.T.C.
Assistant Research Officer—R. J. Warrilow, B.Sc.(Hons.).
Technical Officer—Miss R. I. Shoebridge, B.Sc., Dip.Ed.
Technical Officer—H. F. A. Hergt.
Technical Officer—J. A. Corbett.
Technical Officer—H. T. Philippe.

At University of Western Australia—
Alunite Investigations—
Assistant Research Officer—G. H. Payne, B.Sc., A.A.C.I. (on service leave—R.A.A.F.).
Assistant Research Officer—W. E. Ewers, M.Sc.
Assistant Research Officer—F. C. Johnson, B.Sc.
Librarian—Miss H. P. Meggs (part-time).

16. Section of Biometrics.

At Melbourne—
Senior Research Officer—E. A. Cornish, M.Sc., B.Agr.Sc.
Assistant Research Officer—E. J. Williams, B.Com.
Technical Officer—Miss V. M. Botham, B.Sc.
At Canberra—
Assistant Research Officer—G. A. McIntyre, B.Sc., Dip.Ed.
At Sydney—
Assistant Research Officer—Miss H. A. Newton Turner, B.Arch. (seconded).
Technical Officer—Miss M. Hornsby, B.A.

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Research Officer—F. W. Wood, B.Sc.
Assistant Research Officer—L. S. Prior, B.Sc.
Assistant Research Officer—C. B. Kirkpatrick, B.Sc.
Assistant Research Officer—D. G. Stewart, B.Sc.
Assistant Research Officer—L. Heisler, B.Sc.
Assistant Research Officer—Mrs. M. Harrison, B.Sc.

18. Ore-dressing Investigations.

At University of Melbourne—
Research Officer—J. G. Hart.
Technical Officer—F. D. Drews.
At School of Mines, Adelaide, South Australia—
Assistant Research Officer—D. R. Blaskett, B.E.
At School of Mines, Kalgoorlie, Western Australia—
Officer-in-Charge—B. H. Moore, M.E., D.Sc., F.S.A.S.M., F.A.C.I.
Senior Research Metallurgist—A. C. McDonald, A.S.A.S.M.
Assistant Research Metallurgist and Assayer—R. W. Wilson.
Assistant—W. McA. Manson.

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Officer-in-Charge—F. P. Bowden, Sc.D. (Cantab.), D.Sc., Ph.D.
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Assistant Research Officer (Physics)—J. S. Courtney-Pratt, B.E.
Assistant Research Officer (Chemistry)—A. Yoffe, M.Sc., A.A.C.I.
Assistant Research Officer (Chemistry)—J. N. Gregory, M.Sc.
Assistant Research Officer (Chemistry)—E. B. Greenhill, B.Sc.
Assistant Research Officer (Chemistry)—M. F. R. Mulcahy, M.Sc., A.A.C.I., A.G.Inst.Tech.
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Assistant Research Officer (Chemistry)—M. A. Stone, D.A.C.
Assistant Research Officer (Engineering)—A. E. Ferguson, B.E.E.
Assistant Research Officer (Engineering)—T. V. Krok, B.E.
Assistant Research Officer (Engineering)—G. Tudor, B.E.
Assistant Research Officer (Metallurgy)—A. J. W. Moore, B.Sc.
Assistant Research Officer (Metallurgy)—R. W. K. Honeycombe, M.Sc.
Technical Officer—D. J. Swaine.
Technical Officer—J. F. Peart.

20. Other Investigations.

Dairy Products Investigations—
Officer-in-Charge—W. J. Wiley, D.Sc., A.A.C.I.
Research Officer—E. J. Pont, M.Sc.Agr.
Assistant Research Officer—C. C. Thiel, B.Sc.(Agric.), Ph.D.
Mineragraphic Investigations—
Investigator—F. L. Stillwell, D.Sc.
Research Officer—A. B. Edwards, D.Sc., Ph.D.

4. Publications of the Council.

The following publications were issued by the Council during the year:—

(i) Bulletins.

No. 149.—Production of Dried Grapes in Murray Valley Irrigation Settlements. 2.—Irrigation, Drainage, and Reclamation, by A. V. Lyon, M.Agr.Sc., and A. L. Tisdall, M.Agr.Sc.

No. 150.—The Soils of the Parishes of Longford, Cressy, and Lawrence, County Westmorland, Tasmania. 1.—A Soil Survey of the Area. 2.—Pot Experiments with Subterranean Clover on the Cressy Shaley Clay-loam, by C. G. Stephens, M.Sc., A.A.C.I., J. G. Baldwin, B.Agr.Sc., B.Sc., and J. S. Hosking, M.Sc., A.I.C., A.A.C.I.

No. 151.—The Control of St. John's Wort (*Hypericum perforatum* L. var. *angustifolium* D.C.) by Competing Pasture Plants, by R. M. Moore, B.Sc.Agr., and A. B. Cashmore, M.Sc.

No. 152.—Soil Survey of Part of County Moira, Victoria. (Including the Parishes of Boosey, Cobram, Katamatite, Naringaningalook, Katunga, Yarroweyah, and Strathmerton, by B. E. Butler, B.Sc.Agr., J. G. Baldwin, B.Agr.Sc., B.Sc., F. Penman, M.Sc., R. G. Downes, M.Agr.Sc.

No. 153.—Pelagic Tunicates in the Plankton of South-eastern Australian Waters, and their Place in Oceanographic Studies, by Harold Thompson, M.A., D.Sc. With a Statistical Analysis of Data on Total Plankton, by G. L. Kesteven, B.Sc.

No. 154.—The Handling and Storage of Australian Oranges, Mandarins, and Grapefruit, compiled by F. E. Huelin, B.Sc., Ph.D.

No. 155.—Friction and Lubrication, Report No. 2, The Lubricating Effect of Thin Metallic Films and the Theory of the Action of Bearing Metals, by F. P. Bowden, Sc.D. (Cantab.), and D. Tabor, B.Sc., A.R.C.S., Ph.D. (Cantab.).

No. 156.—Standarized Plant Names—A List of Standard Common Names for the more Important Australian Grasses, other Pasture Plants, and Weeds.

No. 157.—Studies in the Biology of Australian Mullet. 1.—Account of the Fishery and Preliminary Statement of the Biology of *Mugil dobula* Günther, by G. L. Kesteven, B.Sc.

No. 158.—The Recovery of Inter-block Information in Quasi-Factorial Designs with Incomplete Data. 1.—Square, Triple, and Cubic Lattices, by E. A. Cornish, M.Sc., B.Agr.Sc.

No. 159.—Poisonous and Harmful Fishes, by G. P. Whitley, F.R.Z.S.

No. 160.—The Outbreak of the Australian Plague Locust (*Chortoicetes terminifera* Walk.) in the Season 1939-40, with Special Reference to the Influence of Climatic Factors, by K. H. L. Key, M.Sc., Ph.D.

No. 161.—A Review of the Evidence Concerning Expansive Reaction between Aggregate and Cement in Concrete, by A. R. Alderman, M.Sc., Ph.D., F.G.S.

No. 162.—The Soil and Land-Use Survey of the Wakool Irrigation District, New South Wales, by R. Smith, B.Sc.(Agric.), R. I. Herriot, B.Ag.Sc., and E. J. Johnston, B.Sc.Agr.

No. 163.—Transmission of Potato Virus Diseases. 1.—Field Experiment with Leaf Roll at Canberra, 1940-41, by J. G. Bald, M.Agr.Sc., Ph.D., and D. O. Norris, B.Sc.(Agric.). 2.—The Aphis Population of Potatoes at Canberra, during 1940-41, by D. O. Norris, B.Sc.(Agric.), and J. G. Bald, M.Agr.Sc., Ph.D.

(ii) Industrial Chemistry Circulars.

No. 1.—Some Technical Aspects of Foundry Cores, by H. A. Stephens, B.Sc.

No. 2.—Investigations of Low-Tin and Tin-Free Solders, by H. W. Worner, M.Sc., H. T. Greenaway, B.Met.E., and J. H. Buckley, B.Sc.

No. 3.—Melting and Casting of Magnesium Alloys, by H. A. Stephens, B.Sc.

(iii) Quarterly Journal.

Vol. 15, No. 3, August, 1942.
Vol. 15, No. 4, November, 1942.
Vol. 16, No. 1, February, 1943.
Vol. 16, No. 2, May, 1943.

(iv) Annual Report for the year ending 30th June, 1942.

(v) Handbook of Structural Timber Design. Supplement No. 1. Large Timber Structures. Notes on Design, Specification, and Inspection.

XVII. ACKNOWLEDGMENTS.

In various sections of this Report reference has been made to the valuable assistance afforded by many State Departments and other organizations and individuals. The Council desires to express its gratitude for the help given by these bodies and persons in providing laboratory accommodation and other facilities and in many other ways. The Council also wishes to acknowledge the assistance it has received from its State Committees and other Committees, the members of which have placed their knowledge and experience so freely at its disposal.

G. A. JULIUS, Chairman
DAVID RIVETT
A. E. V. RICHARDSON
} Executive Committee.

G. Lightfoot, Secretary.
8th November, 1943.

APPENDIX.

A.—PERSONNEL OF THE COUNCIL AND OF ITS VARIOUS COMMITTEES.

COUNCIL (AS AT 30TH JUNE, 1943).

Executive.

Sir George A. Julius, Kt., D.Sc., B.E., Hon. M.I.E.Aust. (*Chairman*).

Sir David Rivett, K.C.M.G., M.A., D.Sc., F.R.S., F.A.C.I. (*Deputy Chairman and Chief Executive Officer*).

A. E. V. Richardson, C.M.G., M.A., D.Sc. (*Deputy Chief Executive Officer*).

Chairman of State Committees.

Professor I. Clunies Ross, D.V.Sc. (New South Wales).
Professor E. J. Hartung, D.Sc., F.A.C.I. (Victoria).
Professor H. C. Richards, D.Sc., Hon.M.I.E.Aust. (Queensland).
Hon. E. W. Holden, B.Sc., M.I.E.Aust., M.L.C. (South Australia).
E. H. B. Lefroy (Western Australia).
F. H. Foster, B.C.E., A.M.I.E.Aust. (Tasmania).

Co-opted Members.

N. K. S. Brodribb, C.B.E., F.I.C., A.A.C.I.
G. S. Colman, C.B.E.
R. J. Donaldson, D.S.O., B.C.E., M.Aust.I.M.M., M.I.E.Aust.
M. T. W. Eady.
J. P. Tivey, B.A., B.Sc., B.E., M.I.E.Aust., A.M.Inst.C.E.

STATE COMMITTEES (AS AT 30TH JUNE, 1943).

New South Wales.

Professor I. Clunies Ross, D.V.Sc. (*Chairman*).
Professor E. Ashby, D.Sc.
Professor Sir Henry E. Barraclough, K.B.E., V.D., B.E., M.M.E., M.Inst.C.E., M.I.Mech.E., M.I.E.Aust.
Professor W. J. Dakin, D.Sc., F.L.S., F.Z.S.
Professor J. C. Earl, D.Sc., Ph.D., F.I.C., F.A.C.I.
W. R. Hebblewhite, B.E., M.I.E.Aust.
L. St. J. Jones.
Hon. Sir Norman W. Kater, M.L.C., M.B., Ch.M.
Sir Frederick McMaster.
J. Merrett.
R. J. Noble, B.Sc.Agr., M.Sc., Ph.D.
R. G. C. Parry Okeden.
J. G. Peake.
A. R. Penfold, F.I.C., F.A.C.I.
Professor J. D. Stewart, F.R.C.V.S., B.V.Sc.
E. H. F. Swain, Dip. For.
J. P. Tivey, B.A., B.Sc., B.E., M.I.E.Aust., A.M.Inst.C.E.
F. J. Walker.
Professor R. D. Watt, M.A., B.Sc.
C. M. Williams.

Victoria.

Professor E. J. Hartung, D.Sc., F.A.C.I. (*Chairman*).
Professor W. E. Agar, M.A., D.Sc., F.R.S.
W. Baragwanath.
N. K. S. Brodribb, C.B.E., F.I.C., A.A.C.I.
F. M. Burnet, M.D., Ph.D.
G. S. Colman, C.B.E.
M. T. W. Eady.
Sir Herbert W. Gepp, M.Aust.I.M.M., M.Am.I.M.M., F.A.C.I.
Russell Grimwade, C.B.E., B.Sc., F.A.C.I.
G. G. Jobbins, M.I.E.E., M.I.E.Aust.
Sir Dalziel Kelly, LL.B.
Professor W. N. Kernot, B.C.E., M.Mech.E., M.Inst.C.E., M.I.E.Aust.
Emeritus-Professor Sir Thomas R. Lyle, M.A., D.Sc., F.R.S.
H. A. Mullett, B.Agr.Sc.
B. Perry, A.A.C.I.
W. E. Wainwright, A.S.A.S.M., M.Aust.I.M.M., M.Am.I.M.M.
L. J. Weatherly, M.A.
Professor H. A. Woodruff, B.Sc., M.R.C.V.S., L.R.C.P., M.R.C.S.

South Australia.

Hon. E. W. Holden, B.Sc., M.I.E.Aust., M.L.C. (*Chairman*).
A. J. Allen, A.A.C.I.
E. H. Bakewell.
C. E. Chapman, F.I.C., F.A.C.I.
J. H. Gosse.
Professor Kerr Grant, M.Sc., F.Inst.P.
Professor T. H. Johnston, M.A., D.Sc.
F. T. Perry.
Professor J. A. Prescott, D.Sc., A.A.C.I.
W. J. Spafford, R.D.A.
L. K. Ward, B.A., B.E., D.Sc.

Queensland.

Professor H. C. Richards, D.Sc., Hon.M.I.E.Aust. (*Chairman*).
Professor H. Alcock, M.A.
J. D. Bell.
R. J. Donaldson, D.S.O., B.C.E., M.Aust.I.M.M., M.I.E.Aust.
Professor E. J. Goddard, B.A., D.Sc.
V. G. Grenning.
J. B. Henderson, O.B.E., F.I.C., A.A.C.I.
Professor T. G. H. Jones, D.Sc., A.A.C.I.
A. McCulloch, M.E., A.M.I.E.Aust.
A. G. Melville.
J. F. Meynink.
Professor J. K. Murray, B.A., B.Sc.Agr.
Professor T. Parnell, M.A.
Professor H. R. Seddon, D.V.Sc.
R. P. M. Short.
H. C. Urquhart, M.Sc.
R. Veitch, B.Sc.Agr., B.Sc.For., F.E.S.

Western Australia.

E. H. B. Lefroy (*Chairman*).
G. K. Baron-Hay, M.C., B.Sc. (Agric.).
Professor N. S. Bayliss, B.A., B.Sc., Ph.D., F.A.C.I.
H. Bowley, F.A.C.I.
F. G. Brinsden, M.I.M.M., M.Aust.I.M.M.
W. G. Burges.
Professor E. De Courcy Clarke, M.A.
Professor G. A. Currie, D.Sc., B.Agr.Sc.
P. H. Harper, B.A.
S. L. Kessell, M.Sc., Dip.For.
A. L. B. Lefroy.
B. Meecham.
Professor G. E. Nicholls, D.Sc., A.R.C.Sc., F.L.S.
L. W. Phillips, M.Sc., M.Ed., A.Inst.Ed., A.A.C.I.
Professor A. D. Ross, M.A., D.Sc., F.R.S.E., F.Inst.P.
G. L. Sutton, D.Sc.Agr.

Tasmania.

F. H. Foster, B.C.E., A.M.I.E.Aust. (*Chairman*).
N. P. Booth, F.I.C.
Professor A. Burn, M.Sc., B.E., A.M.I.E.Aust.
J. W. Evans, M.A., D.Sc.
F. W. Hicks.
P. E. Keam, M.B.E.
Professor A. L. McAulay, M.A., B.Sc., Ph.D., F.Inst.P.
D. O. Meredith, A.Inst.M.M., M.I.E.Aust., M.A.C.S.
A. K. McGaw, C.M.G.
W. E. Maclean, M.Inst.C.E., M.I.E.Aust.
F. H. Peacock.
Hon. R. O. Shoobridge, M.L.C.
S. W. Steane, B.A., F.R.G.S.

COMMONWEALTH RESEARCH STATION, MERBEIN —CONSULTATIVE COMMITTEE.

B. T. Dickson, B.A., Ph.D., Division of Plant Industry, C.S.I.R. (*Chairman*).
Professor J. A. Prescott, D.Sc., A.A.C.I., Waite Agricultural Research Institute, University of Adelaide.
P. Malloch, Commonwealth Dried Fruits Control Board.
E. J. Casey, Commonwealth Dried Fruits Control Board.

IRRIGATION RESEARCH STATION, GRIFFITH— CONSULTATIVE COMMITTEE.

B. T. Dickson, B.A., Ph.D., Division of Plant Industry, C.S.I.R. (*Chairman*).
Professor J. A. Prescott, D.Sc., A.A.C.I., Waite Agricultural Research Institute, University of Adelaide.
H. N. England, B.Sc., Water Conservation and Irrigation Commission, N.S.W.
E. S. West, B.Sc., M.S., Irrigation Research Station, Griffith (*Secretary*).

COMMONWEALTH RESEARCH STATION, MERBEIN —ADVISORY COMMITTEE.

J. A. Lochhead, Mildura Shire Council (*Chairman*).
L. W. Andrew, Waikerie, South Australia.
P. T. Byrnes, Woorinen, Victoria.
A. E. Cameron, Red Cliffs Settlement.
E. J. Casey (representing Consultative Committee).
J. Gordon, Citrus Growers' Association, Merbein.
W. Grundy, Nyah, Victoria.
S. Heaysman, Coomealla, New South Wales.
W. Heaysman, Cardross Horticultural Society.
A. Lever, Mildura Shire Council.
A. V. Lyon, M.Agr.Sc., Commonwealth Research Station, Merbein.
A. R. McConchie, A.M.I.E.Aust., State Rivers and Water Supply Commission, Victoria.
A. Rawlings, Merbein, Victoria.
S. P. Taylor, Curlwaa, New South Wales.
O. Weste, Renmark, South Australia.
D. C. Winterbottom, Mildura Packers' Association.

IRRIGATION RESEARCH STATION, GRIFFITH—ADVISORY COMMITTEE.

V. C. Williams, Griffith Producers' Co-op. Ltd. (*Chairman*).
C. G. Savage and R. G. Kebby, N.S.W. Department of Agriculture.
E. R. Iredale and C. T. Lasscock, Rural Bank of N.S.W.
H. N. England, B.Sc., and H. J. Braund, Water Conservation and Irrigation Commission, N.S.W.
A. G. Kubank, M.I.A., Pastoral Interests.
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A. G. Strickland, M.Agr.Sc., Department of Agriculture, South Australia.
C. G. Savage, Department of Agriculture, New South Wales.
E. C. Orton, B.Sc., A.I.C., A.A.C.I., Commonwealth Research Station, Merbein.
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A. J. Nicholson, D.Sc., Division of Economic Entomology, C.S.I.R.
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(Formerly the Interdivisional Blowfly Committee; its function is to co-ordinate certain activities of the Divisions of Economic Entomology and of Animal Health and Nutrition.)

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Eric P. Beresford, Moonjaree, Cunnamulla, Queensland.
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E. J. Bowater, Messrs. Angliss & Co., Pty. Ltd., Sydney.
J. M. Davidson, Commonwealth Veterinary Officer, Sydney (representing the Department of Commerce).
J. Merrett, Metropolitan Meat Industry Commissioner, Sydney.
F. J. Walker, Sydney.
J. R. Vickery, M.Sc., Ph.D., A.A.C.I., Division of Food Preservation and Transport, C.S.I.R.

MINERAGRAPHIC COMMITTEE.

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W. E. Wainwright, A.S.A.S.M., M.Aust.I.M.M., M.Am.I.M.M., Australasian Institute of Mining and Metallurgy.

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D. McVey, A.M.I.E.Aust., Postmaster-General's Department, Melbourne.
Lieutenant O. M. Moriarty, R.A.N.V.R., Department of the Navy, Melbourne.
Lt.-Col. B. F. A. Brown, Department of the Army, Melbourne.
Squadron-Leader A. L. Hall, Department of Air, Melbourne.
R. v.d. R. Woolley, M.A., M.Sc., Ph.D., Mt. Stromlo Observatory.
Professor T. Parnell, M.A., University of Queensland.
G. A. Cook, M.Sc., B.M.E., F.A.C.I., C.S.I.R. (*Secretary*).

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Professor Kerr Grant, M.Sc., F.Inst.P., Department of Physics, University of Adelaide.
N. K. S. Brodribb, C.B.E., F.I.C., A.A.C.I., Assistant Director-General of Munitions, Melbourne.
F. J. Shea, M.I.E.Aust., Department of Supply and Shipping, Melbourne.
J. Storey, Aircraft Production Commission.
G. Lightfoot, M.A., C.S.I.R.

B.—COMMITTEES CONCERNING WORK IN WHICH THE COUNCIL IS CO-OPERATING.

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Sir David Rivett, K.C.M.G., M.A., D.Sc., F.R.S., F.A.C.I., C.S.I.R.
J. H. L. Cumpston, C.M.G., M.D., D.P.H., Department of Health, Canberra.

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